March 1961

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FOREWORD

The present issue contains some of the reports for 1959 on the researches conducted under the oceanographic research project of the Japanese National Commission for Unesco, which has been continued since 1953 with the participation of many distinguished marine scientists in Japan.

In 1959, researches were carried out on the marine productivity and its utilization in the Tsushima Warm Current Region to the west of Kyushu and the sea around Kii Peninsula. But since the emphasis was placed on basic research on the productivity in the Tsushima Warm Current Region, the present issue contains the reports pertaining only to this region. The remaining reports will appear in the Regular Number, Vol. 6, No. 1 under the same title which will be published by the Science Council of Japan and in the Special Number 6 which will be published by this Commission.

It is hoped that present number will prove useful to all those abroad concerned with marine sciences.

March 1961

Yoshio Muto
Secretary-General
Japanese National Commission
for Unesco

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THE FUNDAMENTAL INVESTIGATION ON THE BIOLOGICAL PRODUCTIVITY IN THE NORTH-WEST OF KYUSHU I

The Investigation on Plankton

By
Otohiko Tanaka, Haruhiko Irie, Shozi Iizuka and Fumihiro Koga

Introduction

The plankton of the North-west of Kyushu is characterized by the warm Tsushima-current running along the west coast, and is represented luxuriously by many kinds of fauna and flora. The present work aims to elucidate some of the fundamental problems of the plankton production in this region. 27 stations were chosen in the areas of Fukuoka, Hirado, and Sasebo in the North-west coast of Kyushu (Fig. 1). The routine works of observation were carried out by collecting water samples and plankton bimonthly in Fukuoka area from June, twice a week in Sasebo Bay from July, and 4 times in the neighbouring waters of Hirado Island from June to December in 1959.

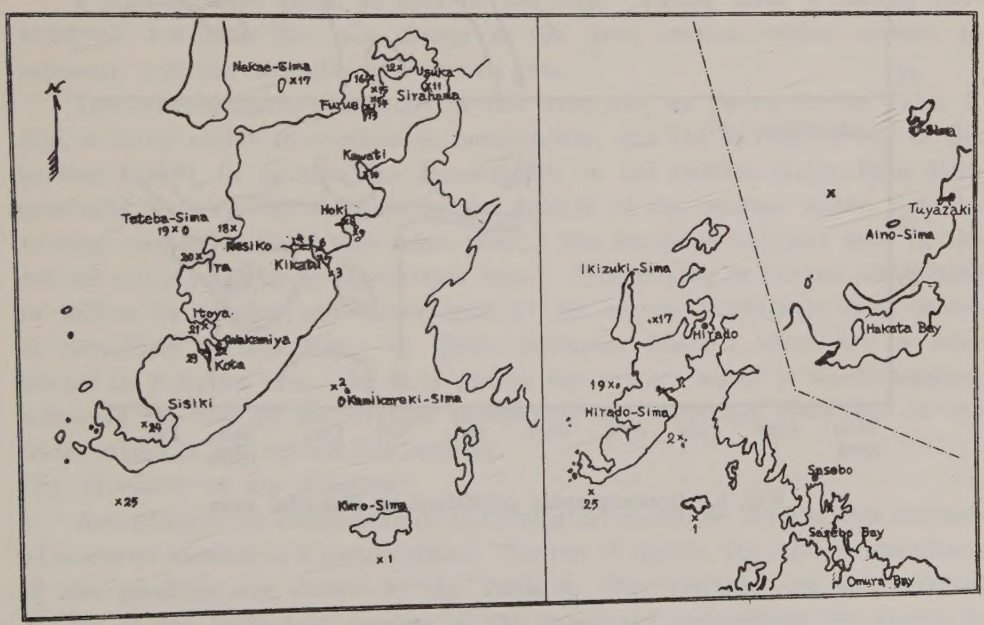

Fig. 1. Station of observation at Fukuoka, Hirado and Sasebo areas

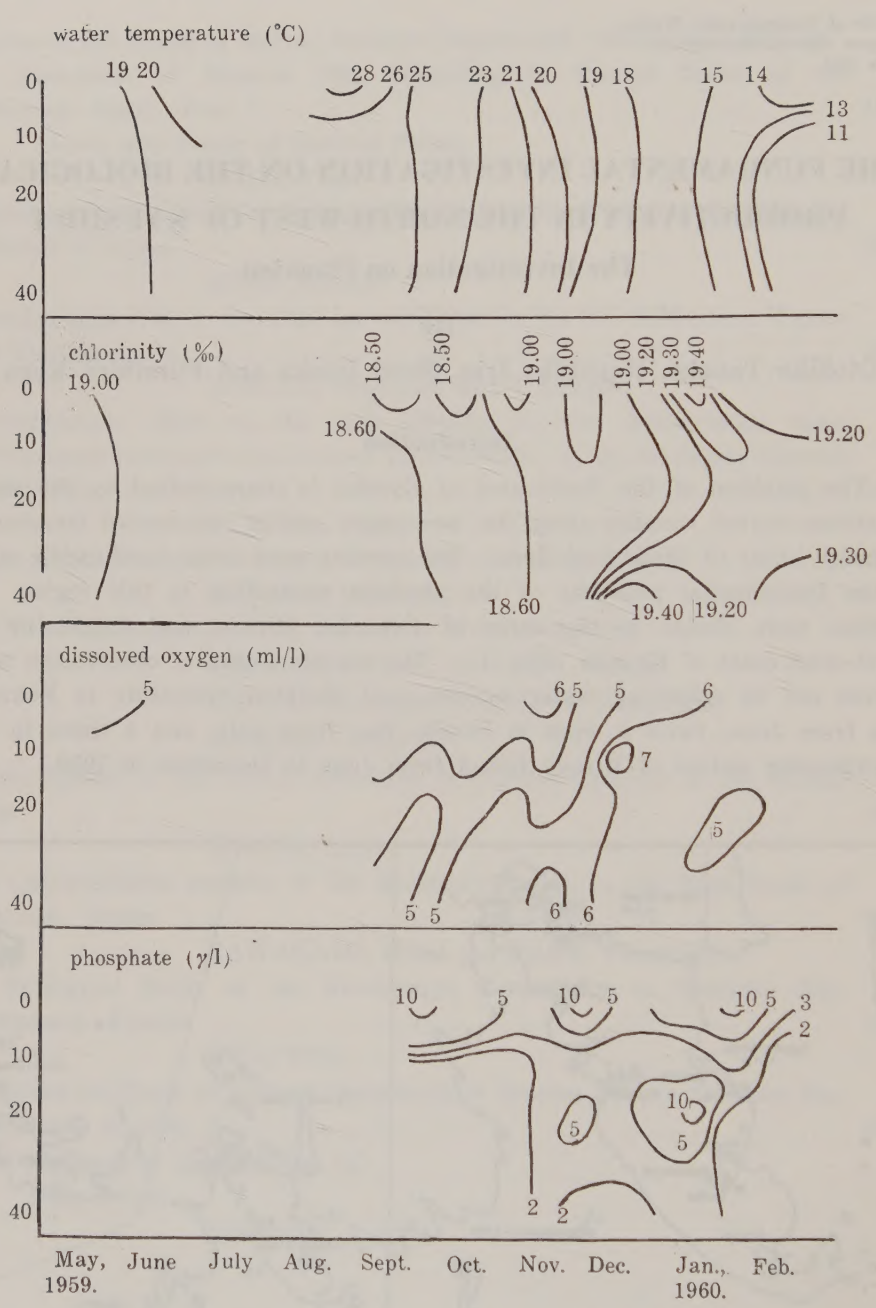

Fig. 2. Oceanographic conditions in Fukuoka area

Methods

Temperature, salinity, dissolved oxygen, nutrient salts (phosphate, nitrate, nitrite and silicate) and soluble organic matter were observed at each station, the samples of bottom mud were collected in some stations in the neighbouring waters of Hirado Island to see the grain-composition and organic content of the sediments. The turbidity of water was determined from measurement of absorption coefficient of the water samples in the cuvette (2 cm), condensed to 25 ml by centrifuging 1 litre of sea water.

Macroplankton was collected with the Uchida's larval net (conical, mouth diameter 1 m, lateral length 3 m) made of bolting silk GG 54 by towing for 10 minutes in the surface and 20 meter layers. For microplankton collection the NORPAC-type net was used vertically from the bottom to the surface. The population per cubic metre was calculated. In preparing chlorophyll determination 20 litre of water in Fukuoka area and 5 litre of water of Sasebo Bay were filtered and the chlorophyll of the phytoplankton extracted with acetone. The concentration of chlorophyll was determined with spectrophotometer. In Sasebo the intensive study was made to correlate the concentration of chlorophyll and the number of diatom cell.

Results

1. Fukuoka Area

(1) Remarks on oceanographic conditions

4 stations were taken at first in the area. Among these a station (33° 48′30″ N, 130°26′30″ E) was chosen as the fixed station, which deemed to represent well the character of Fukuoka area.

The oceanographic conditions in this area are, as shown in the Table 1, Fig. 2 fairly stable in summer in temperature, and the salinity is low in the surface layer. In autumn the temperature of the surface water falls down gradually, causing the increase in the density of the surface water, and the vertical mixing of the water takes place. The available nutrient salts in the bottom water come up to the surface layer. This mixing is further accelerated in winter by cooling and disturbance by the strong North-west wind which is prevailing in this area. In these conditions diatoms burst out in later winter in Fukuoka area. In early spring the surface water is warmed again, following the rise of the surface temerature and stabilized conditions of the water layers in late spring and summer.

(2) Remarks on the plankton

According to the oceanographic and biological conditions the plankton succeeded one after another in 6 communities. The list of species, the relative abundance of the plankton are shown in the Table 2. The biomass and the seasonal change of the individual number of the important zooplankton are shown in the Table 1 and in the Figs. 3, 4 and 5.

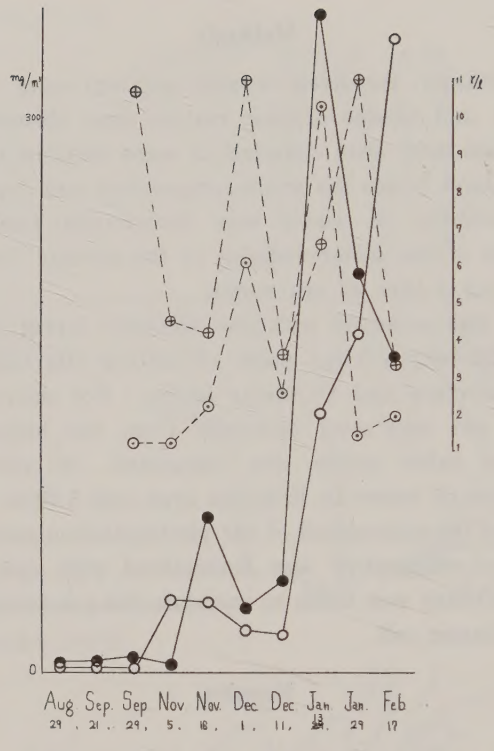

Fig. 3. Seasonal variation of wet weight of plankton and phosphate in Fukuoka area
(empty circle: surface, solid circle: 20 m)
(⊕ : surface ◉ : 20 m)

May. In this month zooplankton species is not rich. *Penilia schmackeri, Noctiluca scintillans* and microcalanids are the main constituents, among which *Penilia* is most dominant.

June. The plankton species is poor in this month. The zooplankton is chiefly composed of *Penilia schmackeri,* microcalanids. The phytoplankton is represented by *Thalassiosira subtilis.*

August. The plankton species is fairly abundant but phytoplankton is poor both in quality and quantity. *Penilia schmackeri* and *Pyrocystis noctiluca* are the common species.

September. The phytoplankton suddenly increases in this month, the plankton species are abundant, and are represented by *Rhizosolenia alata f. indica, Biddulphia longicruris.* The zooplankton is also rich in species, they are *Sagitta enflata, Calanus vulgaris, Eucalanus pileatus, Lucifer typus, Oikopleura rufescens.*

October. The rich zooplankton is predominated by *Lucifer typus, Eucalanus pileatus, Centropages furcatus, Labidocera acuta* and *Oikopleura rufescens.* Among them *Lucifer* is most abundant. *Rhizosolenia alata f. indica* is still dominant in this month.

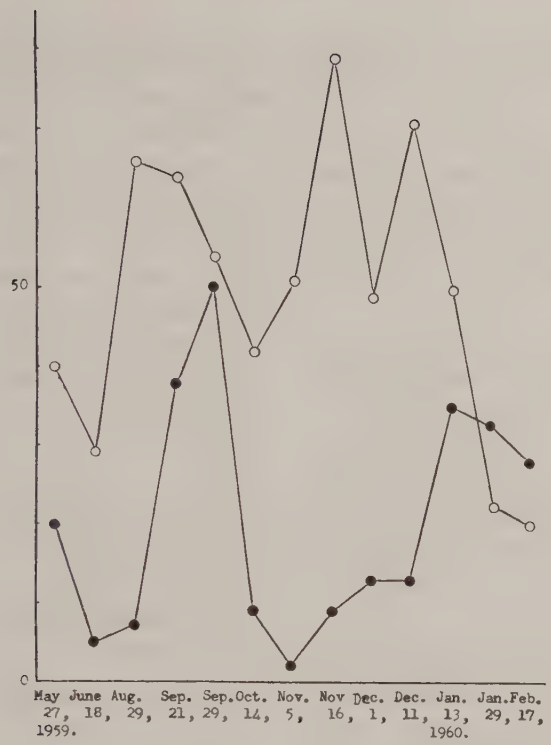

Fig. 4. Seasonal variation of the number of plankton species in Fukuoka area

November. The zooplankton is richest in this month and mainly composed of the pelagic species of warm waters. The phytoplankton, on the other hand, decreases rapidly in this month.

December. The phytoplankton is very poor except *Triceratium gibbosum*. The zooplankton flourishes still in this month. *Sagitta enflata, Oikopleura rufescens, Dromosphaera polygonalis, Limacina* sp., *Eucalanus subtenuis, Pareuchaeta russelli* and *Ophiopluteus* larvae are very common.

January. Most of zooplankton disappear in this month. On the contrary, phytoplankton population starts to increase and reaches its maximum. Above all *Thalassiosira subtilis* is most dominant.

February. Many kinds of phytoplankton are still dominant. *Noctiluca scintillans* begins to increase in this month. Appearance of the voracious *Noctiluca* is so striking in this area, that the coastal water is covered with dense film of *Noctiluca* and causes often the death of fishes kept in preserve basket. From the results of the seasonal succession of the plankton the following 6 communities are recognized.

(i) *Penilia schmackeri* community (Summer community)

The phytoplankton in this season is very poor owing to the reduced growth rate due to deficiency of available nutrient salts caused by the stagnation of

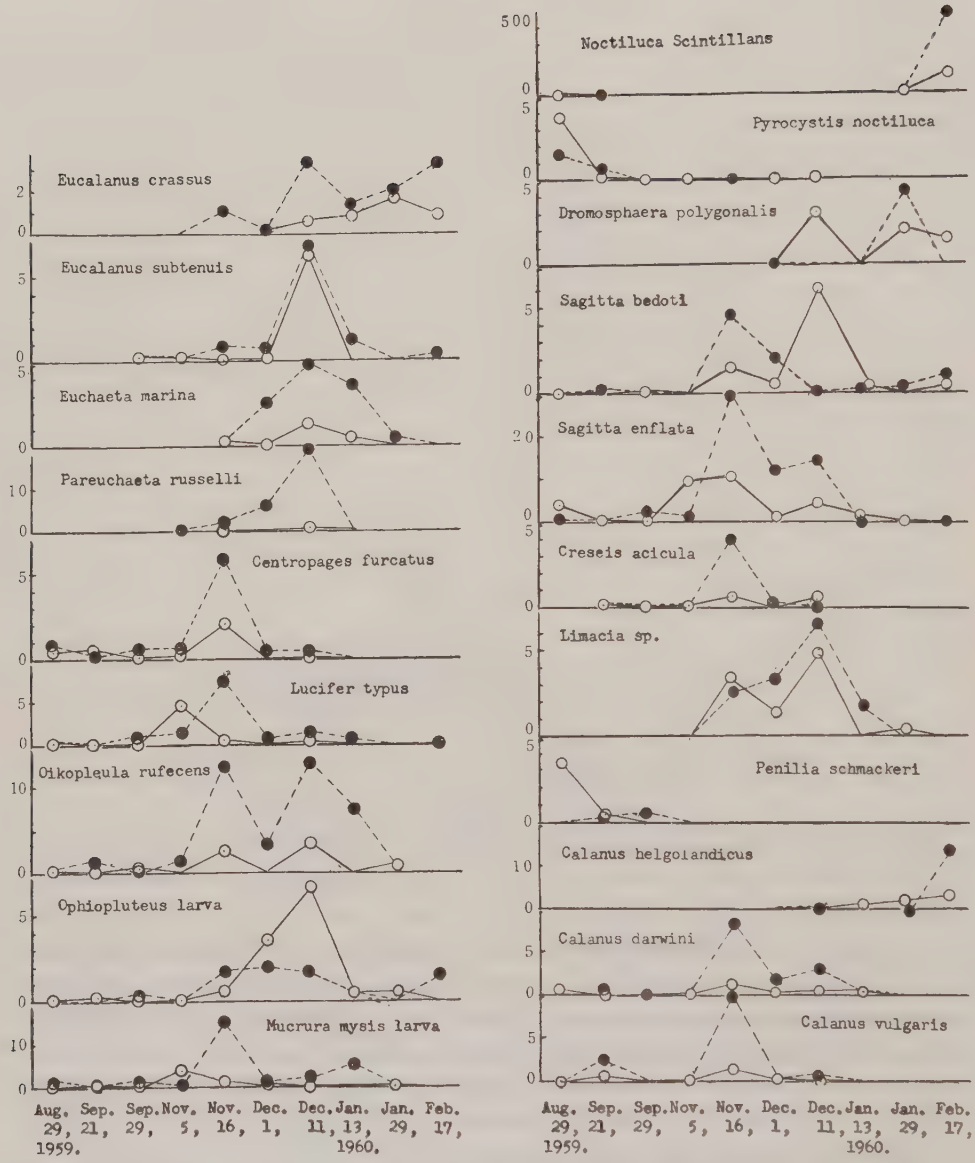

Fig. 5. Seasonal variation in the number of important zooplankton species in Fukuoka area
(empty circles: surface, solid circles: 20 m)

water, and increased rate of grazing by copepods and *Noctiluca*. But the zooplankton population is not necessarily abundant. It is represented by *Penilia schmackeri, Evadne tergestina, Pyrocystis noctiluca* and microcalanids.

(ii) *Rhizosolenia alata* community (Early autumn community)

The phytoplankton is abundant as in the vernal blooming. This is caused by the decrease of zooplankton population and the increased amount of the

nutrient salts brought to the surface layer by vertical mixing. The phytoplankton species is most abundant in this period during the whole year, and is dominated by *Rhizosolenia alata f. indica* and *Biddulphia longicruris*. The zooplankton is represented by warm water species, such as *Calanus vulgaris*.

(iii) *Sagitta enflata* community (Autumn-early winter community)

In this season the warm Tsushima current washes violently over the coast and carries a great deal of the pelagic life in our area. Many kinds of zooplankton appear associated with the phytoplankton increased in the early autumn. The phytoplankton, on the other hand, decreases gradually by heavy grazing of zooplankton. *Sagitta enflata, Limacina* sp., *Calanus vulgaris, Calanus darwini, Pareuchaeta russelli, Lucifer typus, Oikopleura rufescens, Salpa fusiformis, Ophiopluteus larvae, Brachyuran zoea* and *Macruran mysis* are the common species.

(iv) *Thalassiosira subtilis* community (Winter community)

The rich zooplankton of the early winter suddenly disappears and becomes very poor both qualitatively and quantitatively in this season on account of the paucity of the phytoplankton consumed in autumn to early winter period, and also of the fall of water temperature. On the other hand, a species of diatom, *Thalassiosira subtilis* burst out so vigorously that thousands of the colonies of the diatom cells clog the meshes of plankton net in a few minutes. This species was also abundant in the Hirado area in the second ten days of December, 1959. The species was also common in Wakayama area, but scarce in Kagoshima area in 1959. *Chaetoceros socialis* increased also in a great quantity almost as large as *Thalassiosira subtilis*. *Calanus helgolandicus* appears in this season in the Kyushu area.

(v) *Noctiluca scintillans* community (Spring community)

Noctiluca scientillans dominates in the later half of this season. The phytoplankton rapidly declines by the heavy grazing of *Noctiluca*. Among zooplankton *Acartia clausi* and *Corycaeus affinis* are common in the coastal water, and *Calanus helgolandicus* in the offshore water. *Thalassiosira subtilis, Coscinodiscus wailesii* and *Coscinodiscus gigas* are the representatives of the offshore water.

(vi) *Paracalanus parvus* community (Early summer community)

This community is characterized by poor phytoplankton population, which is mainly composed of *Coscinodiscus wailesii, Thalassiosira subtilis* and *Coscinodiscus gigas*. On the other hand, the neritic species of zooplankton, such as *Acartia clausi, Corycaeus affinis* and *Paracalanus parvus* occur commonly in the coastal water. *Paracalanus parvus* and *Calanus helgolandicus* are also common in the offshore water. Sometimes dense patches of *Calanus helgolandicus* occur in Fukuoka area.

2. Neighbouring waters of Hirado Island

(1) General remarks on the oceanographic conditions (Table 3)

The water temperature of the east side of the Island is rather high in

June and August but it is quite different in December, that the circumstances in the offshore water are somewhat higher than the inshore. The salinity in the western offshore water is rather high in June and August. But in the inshore, on the contrary, there are no remarkable differences in salinity and dissolved oxygen in both sides. In December there is no distinct difference in salinity between the eastern and western sides and also between the waters offshore and inshore. The salinity is rather high in December than in June and August.

The vertical distribution of salinity and temperature in the offshore water were comparatively stable in June and August, but became obscure in December, and that this circumstance was more remarkable in the west side. In general, water is turbid and water colour is striking in the east side and less turbid in the west side. Plant nutrients and soluble organic matter were less in quantity in the west side in July, but increased in August and December. Organic carbons were rather abundant in June and August on the east side, but not remarkable in December.

From above, we have the following results.

(i) During the whole year, inshore water dominates in the east side and the offshore water in the west side.

(ii) The offshore water has a slight influence upon the water of the east side in summer.

(iii) Vertical mixing occurs on the both sides in winter.

(iv) Irregular coastal line and the drainage from rivers and exposure to the open sea are the causes of the complicated hydrographic conditions in Hirado area.

(2) General remarks on plankton communities (Table 4, 5, 6)

(i) In general, there was no remarkable qualitative difference in June and August on the both sides, but the east side was rather abundant in June and the west side in August. But rich plankton is found in the east side both in quality and quantity in December.

(ii) The shore water was rich in plankton on each side in June and December, but no remarkable difference was observed between the inshore and the offshore in August.

(iii) During the whole year, the genus *Chaetoceros* dominated remarkably, but in August *Bacteriastrum* and *Thalassiosira* dominated over *Chaetoceros*. In December *Thalassiosira subtilis* was exclusively dominant on the east side.

(iv) Fish-eggs were abundant on the west side in June but larvae on the east side, but in August there was no remarkable difference between east and west sides. Anchovy-eggs occurred abundantly in August and December only on the west side.

(v) Microcalanid-copepods dominated in December on the west side.

(vi) Crustacean larvae and arrow-worms dominated on the east side, appendicularians and amphipods on the west side in June, but first 3 forms

dominated on the west side in August, but amphipods was absent on both sides. In December, crustacean larvae and amphipods remarkably dominated on the west side, and the first appearance of *Lucifer*, and that in a great quantity, on the western side is worthy of special interest.

3. Pigment and cell number of phytoplankton in coastal region of Sasebo Bay

By means of spectrophotometer, the authors observed quantitatively long-term variations of the pigment amount and cell number of phytoplankton at the station in Sasebo Bay (Fig. 1) and tried to elucidate the relations between pigment amount and cell number. However, we were insufficiently prepared in the methods of pigment extraction: in the first place the water samples were placed on ordinary paper filter (Toyo-No. 2) instead of Membranfilter or Millipore filter to collect phytoplankton, and in the second place the extraction was done only for 20 minutes under the room temperature after immersing the filter in absolute acetone. The absorbancies, E_{435} or E_{670}, were used directly to show the pigment amount; so they do not mean the absolute amounts of chlorophyll or xanthophyll. Observations were carried out during the period from April 20, 1959 to February 29, 1960, and it was confirmed from analysis that the relations between the pigment amount and cell number were very complex and not always so simple as we had expected.

Method

For the extraction of the pigments 5 litres of water and for cell counting one litre of water were used. These samples for extraction being filtered by ordinary paper filter (Toyo-No. 2), the filtrate was put in the test tube and 10 ml of absolute acetone was poured into it with about 0.2 gr of powdered magnesium carbonate and was stirred. Then, the corked tube was placed in dark for about 20 minutes. The extract was centrifuged for 5 minutes (3,000 rov. per minute), and each absorbency at 10 mμ interval from 400 to 700 mμ was determined on a Beckman Model DU type spectrophotometer and was determined at 5 mμ interval in the 2 main absorption bands. The samples for counting cell number were fixed by formalin and were concentrated after 3 or 4 days until 25 ml by settling and centrifuging methods. 0.1 ml of them was picked out by the stempel-pipette and total cell numbers were counted. This procedure was repeated 5 times, and the results were converted into the cell number per 1 litre.

Results

(1) Spectral absorption curve of absolute acetone extract

The height of curve drawn to connect the absorbencies at each wave length was variable depending on the pigment amount of the sample. The form of the curve is nearly the same, two maxima being generally observed at the absorbencies of 435 and 670 mμ by the quality of pigment in the sample. Now, naming two maxima at 433 and 670 mμ as E_{435} and E_{670}, the ratios of E_{435} to E_{670} were in most cases 3.5 but ranged from 1.8 to 8.1 throughout the whole period of the observation. These differences of ratio were probably due to the

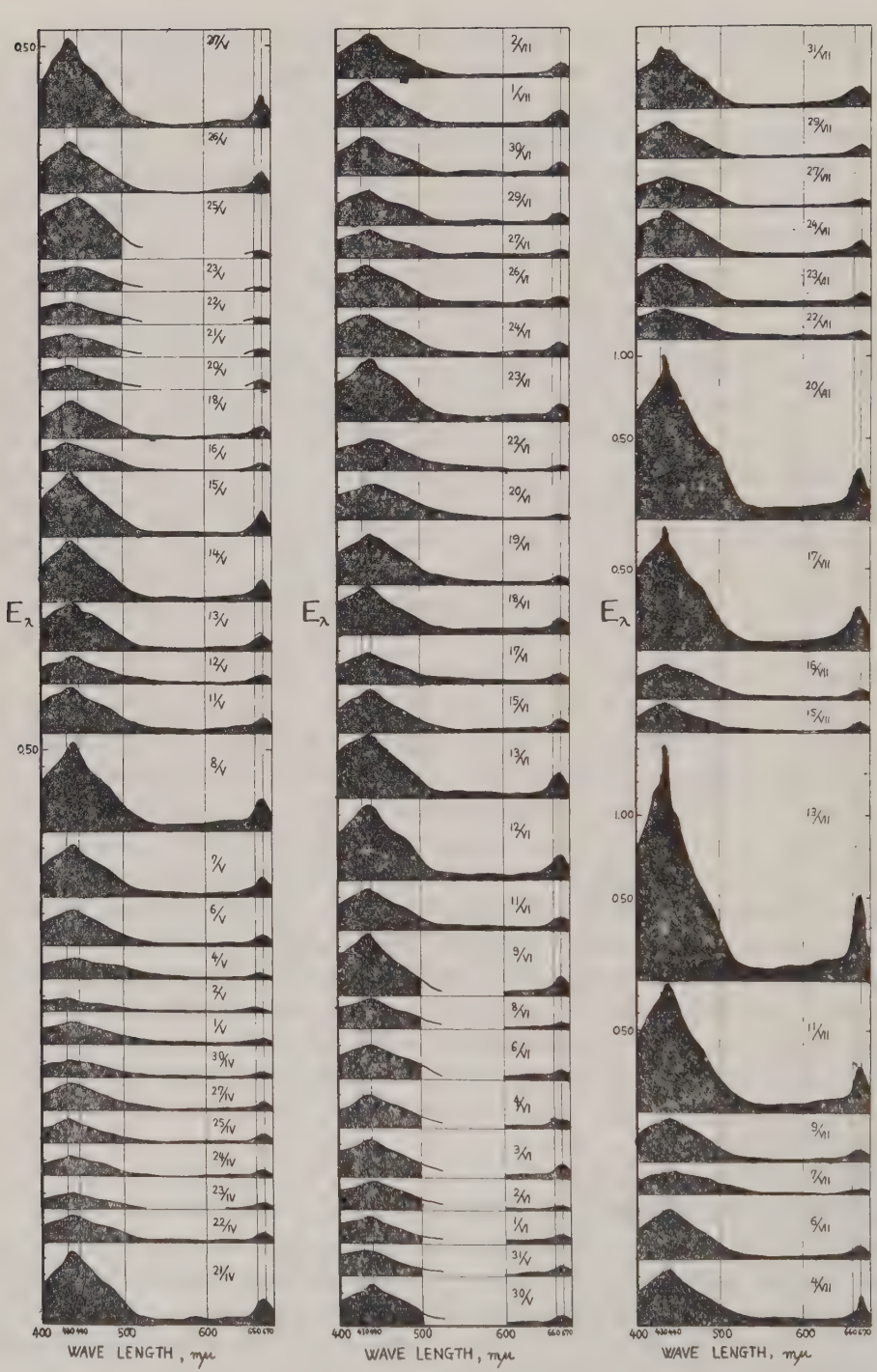

Fig. 6. Successional occurrences of spectral absorption curve in the surface collection at Sakibe Station, from April 21 to July 31, 1959

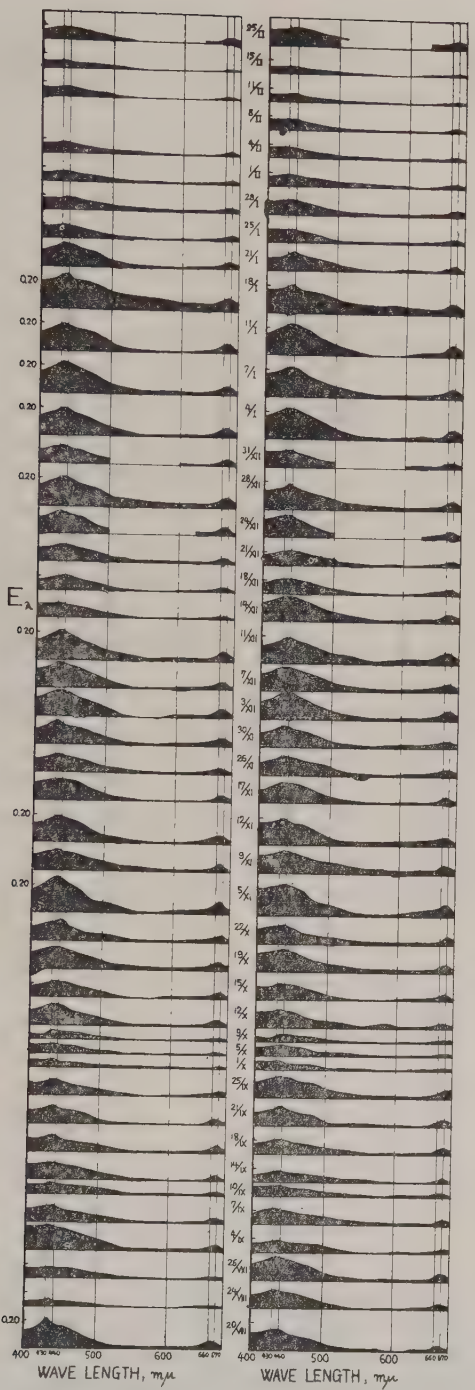

Fig. 7. Successional occurrences of spectral absorption curve in the surface (left) and bottom (right) collection at Sakibe Station, from August 21, 1959 to February 25, 1960

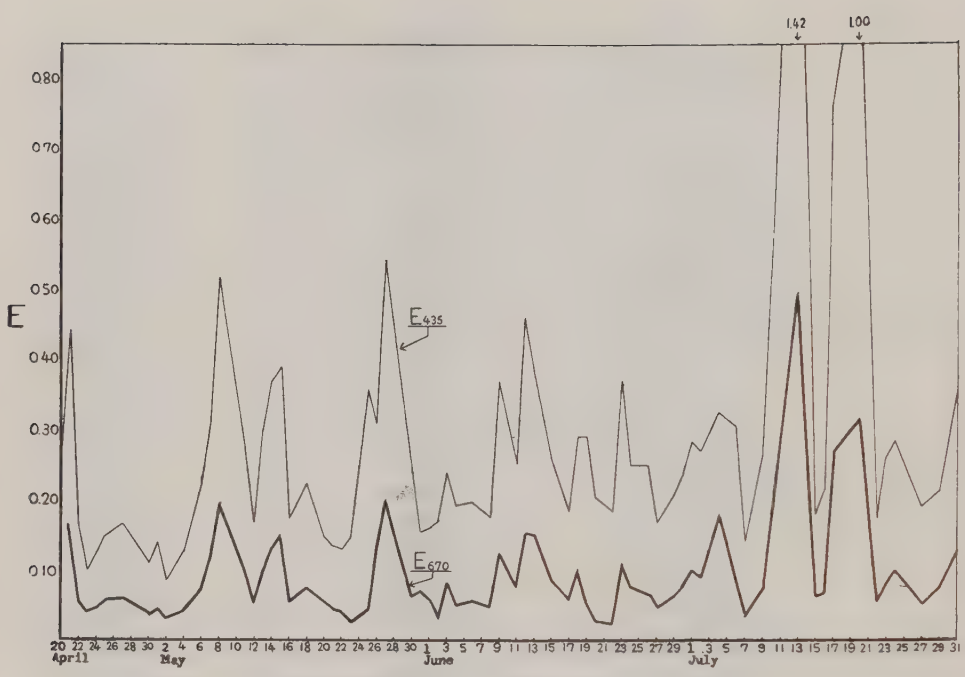

Fig. 8. Seasonal occurrences of E_{435} and E_{670} in the surface collection, at Sakibe Station, from April 20 to July 31, 1959

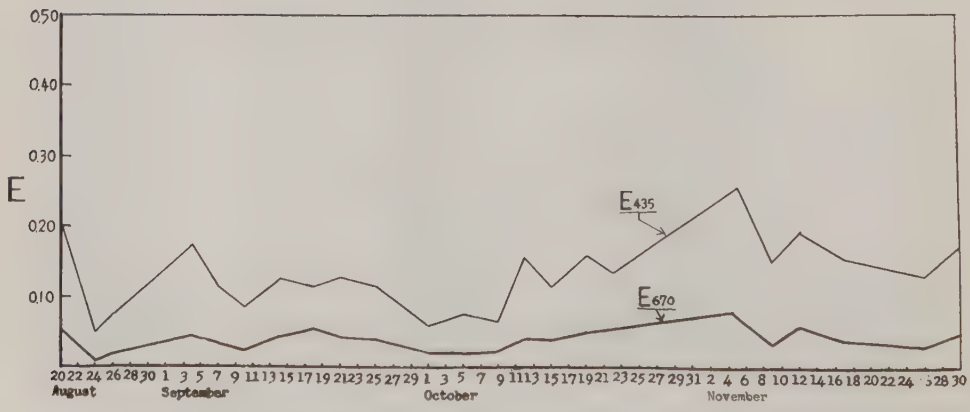

Fig. 9. Seasonal occurrences of E_{435} and E_{670} in the surface collection, at Sakibe Station, from August 20 to November 30, 1959

quality of pigment. The ratio will show indirectly the relative proportion of the amount of xanthophyll to chlorophyll. The typical form of the absorption curve is shown, as an example, by the curve obtained on July 13 in the figure 1. These figures, 1 and 2, illustrate the succession of the curve in each sample.

(2) Seasonal occurrence of E_{435} and E_{670}

The monthly values of E_{435} and E_{670} in the whole period of observation are shown in the Table 7, 8, and Figs. 6 to 10. As is shown in the Table 7, E_{435} and E_{670} values are during April to June higher than the average and in other months these values are smaller. The vaules are exceedingly large in May, June and July and this coincides with the period of phytoplankton blooming succeeding from the first decade of May to July. The value was highest in July owing to the high values in July 13 and 20 which were 4 to 5.5 times as high as an usual value. But judging from the cell number in these two days the phytoplankton population was diminishing in July and it is questionable why the values observed on these two days are so high. The decrease in value in the days between July 13 and May 20 is probably caused by the temporary disappearance of surface phytoplankton due to heavy precipitation. The second high value appeared early in the cold months from November to January, but it was only a half as high as the first. The low values appeared in October and February, especially, it was minimum in February and is less than 1/5.5 of the value in July.

(3) Phytoplankton cell count and composition of the species (Table 8)

Genera *Skeletonema* and *Chaetoceros* were dominant all over the period and genera *Leptocylindrus, Rhizosolenia, Thal'nema, Nitzschia* and *Asterionella* succeeded to the first group. Cell number of the members other than genera *Skeletonema* and *Chaetoceros,* however, were so small that total number of the

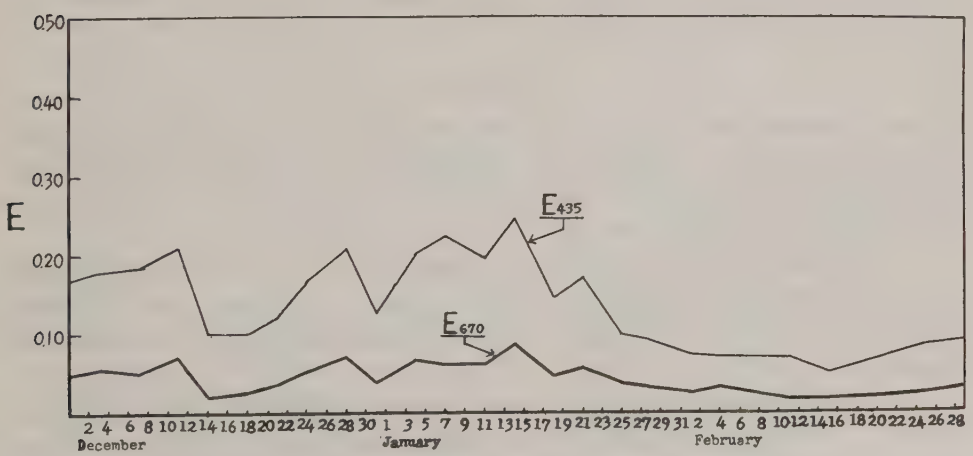

Fig. 10. Seasonal occurrences of E_{435} and E_{670} in the surface collection, at Sakibe Station, from December 1, 1959 to February 29, 1960

cell of other genera combined did not amount to those of two genera mentioned above. Therefore, for preparation of the table (Table 8) showing the cell number and composition, the authors divided diatoms into three groups; i. e. *Skeletonema, Chaetoceros,* and other genera. According to our unpublished data, the authors realize that the phytoplankton population was poor in March and April. After this long desert period, the phytoplankton slowly started to increase at the first decade of May. In the middle decade of the month cell number attained to maximum throughout the year. This flourishment continued until the end of July accompanied with altering rate of increase. The amount of precipitation during July 13 to 15 reached to 234.5 mm and for this reason the plankton community disappeared for some days from the surface but soon recovered its normal growth after a week and flourished again. It is most probable that phytoplankton vanished in the period from first decade to the middle in August, and afterward, cell number began to decrease gradually, which was followed by the secondary desert period in October and November although there was a small increase in September. Next increase occurred in December. The maximum and minimum of cell number in the period of observation were approximately 4,500,000 and 7,000 cells per litre respectively, averaging 600,000 cells per litre. The communities were usually composed of *Skeletonema* and *Chaetoceros,* but *Skeletonema* always prevailed to *Chaetoceros.* In autumn, some genera of the third group, for example *Rhizosolenia* or *Nitzschia,* exceeded *Skeletonema* or *Chaetoceros* only in several cases.

Dinoflagellates occurred abundantly in the cold months and during a certain period in summer but were sparse during flourishing or desert period of the diatoms. They were consisted of 500 cells per litre in average and *Ceratium furca* was most frequent. Silicoflagellates occurred occasionally, among which *Dictyocha fibula* and *Distephanus* were dominant. Their average cell number was approximately 300 per litre and was more abundant in the bottom layer than in the surface as in Dinoflagellates.

Summary

1. Oceanographic conditions of waters and plankton communities were investigated to elucidate some of the basic problems of the plankton productivity in the Fukuoka, Hirado, and Sasebo areas in the north-west of Kyushu from April, 1959 to February, 1960.

2. Stagnation of water occurs in summer, and vertical mixing of water appears in winter in Fukuoka and Hirado areas. In Hirado area the coastal water is distributed in the eastern region and the oceanic water in the western region.

3. Six plankton communities were observed in Fukuoka area throughout the year. The plankton species in the eastern and western regions of Hirado area are in the main similar in composition, and the coastal water is very productive

4. There are 2 maxima in the phytoplankton population. They are spring and early autumn maxima. Rich production of phytoplankton induces a big increase of zooplankton. The biomass of zooplankton reaches the maximum in the late autumn and lasts to the early winter.

5. *Thalassiosira subtilis* is very dominant in spring. The species appears in December in Hirado area and in January in Fukuoka area. This enormous amount of the species affects seriously the fisheries in these areas.

6. The seasonal change of the phytoplankton communities was observed in Sasebo in accordance with the chlorophyll content of the diatom cell. The fluctuations of phytoplankton population were estimated by the absorption coefficients of chlorophyll and it revealed in Sasebo area that the ratio between chlorophyll and xanthophyll will indicate the relative abundance of xanthophyll to chlorophyll. Further, the relation between cell number and the composition of the species was studied.

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Table 1. Oceanographic conditions in Fukuoka area

Date		May 27, 1959.	June 18,	Aug. 29,	Sept. 21,	Sept. 29,	Oct. 14,	Nov. 5,	Nov. 16,	Dec. 1,	Dec. 11,	Jan. 13, 1960.	Jan. 29,	Feb. 17,
Time		10.00–11.00	10.00–11.00	11.00–12.00	11.00–12.00	10.00–11.00	15.00–16.00	15.00–16.00	15.00–16.00	15.00–16.00	14.00–15.00	14.00–15.00	14.00–15.00	12.00–13.00
Weather		cloudy	Fine	Fine	Fine	Fine	Fine	Fine	Fine	cloudy	cloudy	Fine	Fine	cloudy
Air temp. (°C)		19.5	22.0	28.5	24.9	24.0	16.0	19.6	18.1	16.1	15.8	9.7	8.4	9.7
Wind		N-1	N-2	SW-3	NW-2	N-3	N-3	N-2	N-4	SW-2	SW-2	W-1	NW-4	N-2
Wave		1	2	3	2	3	2	2	4	2	2	1	4	2
Transparency (m)					15	9.5	13.8	12.5	4	7.5	16.3	17.3	8.7	13.6
Colour of sea				3	3	4	3	4	4	3	3	3	3	3
Water temp. (°C)	Depth (m)													
	0	18.40	20.10	28.30	25.60	24.20	23.10	21.00	19.50	19.00	18.60	15.50	13.80	14.20
	10				25.57	24.02	23.02	21.60	20.59	19.22	18.60	15.56	13.62	10.37
	20	18.23	19.10		25.51	23.87	23.10	21.62	20.70	19.22	18.60	15.01	13.45	10.32
	40	18.14	19.10		25.43	23.50	22.99	21.62	20.49	18.88	18.60	15.69	13.02	10.32
Cl ‰	0	18.96	18.81		18.46	18.51	18.42	19.02	18.64	19.26	18.82	19.43	19.05	19.06
	10				18.77	18.53	18.56	18.60		19.06	18.82	19.14	19.33	19.23
	20	19.01	18.81		18.76	18.52	18.50	18.59	18.61		18.85		19.22	19.23
	40	18.98	18.81		18.93	18.57	18.56	18.58	18.60	18.88	19.48	19.31	19.26	19.37
O_2 ml/l	0	5.02	4.99			5.04	5.16	5.21	6.04	4.97		5.16	6.74	6.78
	10				5.82	4.65	5.49	4.89	5.66	4.96	7.21	6.23	6.24	6.35
	20	4.93	4.85		4.64	5.14	4.68	5.16	4.89	5.26	5.97		5.95	6.01
	40	4.93	4.82		5.36	4.42	5.42	5.50	6.02	5.00	6.42	6.05	6.34	6.33
Po_4 γ/l	0					10.7		4.5	4.2	11.0	3.6	6.6	11.0	3.3
	10					1.9		1.3	2.4	2.9	2.3	2.2	3.9	1.1
	20					1.2		1.2	2.2	6.1	2.6	10.3	1.4	1.9
	40					1.2		1.4	2.2	1.2	1.3	2.9	1.9	1.1
Settling volume of plankton cc/m^3	0~40	3.8	3.4	1.25	3.5	2.8	3.8	1.7	2.2	0.56	1.25	13.4	30.3	21.6
Wet weight mg/m^3	0			3.6	3.2	2.8		39.2	38.8	24.0	20.4	140.0	184.4	342.0
	20			4.4	6.0	9.2		4.8	84.8	36.0	70.0	358.8	216.4	172.0
No. of Zooplankton Individuals	0			16.1	8.3	2.0		11.6	37.0	13.0	45.2	11.0	15.6	126.0
	20			15.1	8.4	9.9		8.2	141.3	56.4	102.9	45.9	21.6	510.1
No. of species		59	34	73	102	104	51	53	88	62	84	75	55	48
Chlorophyll (Eλ)						0.475	0.225	0.475	0.860	0.860	0.375	0.925	1.065	0.790

Table 2. Relative abundance of plankton and list of species in Fukuoka area

	May 27, 1959.	June 18,	Aug. 29,	Sept. 21,	Sept. 29,	Oct. 14,	Nov. 5,	Nov. 16,	Dec. 1,	Dec. 11,	Jan. 13, 1960.	Jan. 29,	Feb. 17,
CYANOPHYCEAE													
Skujaella Hildebrandtii (Gomnt) J. de Toni			c c	c c c									
BACILLARIACEAE													
Melosira sulcata (Ehrenberg) Kützing													r r
M. sp.					r r r								
Coscinodiscus Janishii A. Schmidt					r r								
C. radiatus Ehrenberg									r r	r r			
C. wailesii Gran & Angst	r	c							r		r r	r	c
Hemidiscus cuneiformis Wallich				r							c	c	
Lauderia borealis Gran					r						c	c	c
L. graciris Grun.											r r		
Thalassiosira condensata (Cleve)				r r	r r							r	
T. subtilis (Ostenfeld)	c	c c		r r	r r		r r		r	r	c c c	c c c	c c c
Skeletonema costatum (Greville)	r r												
Stephanopyxis palmeriana (Grev.)	r	r		r	r	r		r			c c	c	c c
S. nipponica Gran & Yendo				r r	r r						r r	r r	
Dactyliosolen mediterraneus Peragallo	r		r r		r r							r r	
Leptocylindrus danicus Cleve											r	r r	
Guinardia flaccida (Castracane) Peragallo				r	r			r		r	r	r	r
Rhizosolenia alata Brightwell				r	r			c c	c	c	c	c	c
R. alata f. gracillima (Cleve) Grunow	r												
R. alata f. indica (Perg.) Ostenfeld			r r	c c c	c c c	c				c	c	c	c
R. alata f. inermis (Castr.)											r r		
R. Bergonii Pergallo													
R. calcar avis M. Schultze		r r		r	r						r r	r r	
R. Clevei Ostenfeld				r r r	r r r								
R. fragilissima Bergon						r r							
R. hebetata (Bailey) Gran													
R. hebetata f. semispina (Hensen) Gran								r			r r		

	May 27, 1959.	June 18,	Aug. 29,	Sept. 21,	Sept. 29,	Oct. 14,	Nov. 5,	Nov. 16,	Dec. 1,	Dec. 11,	Jan. 13, 1960.	Jan. 29,	Feb. 17,
R. stolterforthii Peragallo	r r			r								r r	r
R. styliformis Brightwell	r	r	r r	r	c	r		r r	r	r	r	r r	r
R. styliformis var. latissima Brightwell	r r				r r				r r	r	r	r r	r r
Bacteriastrum comosum Pavillard	r			r	r						r	r	r r
B. delicatulum Cleve				r r									
B. hyalinum Lauder										r r			
B. hyalinum var. princeps (Castracane)					r r								
B. mediterraneum Paillard					r r								
B. varians Lauder				r r	r								r r
B. sp.					r r								
Chaetoceros borealis Bailey								r	r	c	c	c	c
C. coarctatus Lauder			r r	r r	r r								
C. densus Cleve											r r	r r	
C. denticulatum Lauder									r r	r r			
C. Eibenii Grunow			r r		r r								
C. okamurai Ikari				r r	r r								
C. peruvianus Brightwell				r r									
C. affinis Lauder				c	c						c	c	
C. brevis Schütt				r r	r r								r r
C. compressus Lauder					r r								
Chaetoceros curvisetus Cleve				r r	r r						r r		
C. decipiens Cleve													
C. didymus Ehrenberg	r r			r	r						r r	r r	r r
C. distans Cleve				r	r								
C. diversus Cleve				r r									
C. laciniasus Schütt					r r								
C. Lorenzianus Grunow				c	r			r	r		r r	r	r
C. messanensis Castrcane				c	c							r r	
C. paradoxum Cleve				r r	r r								
C. pseudocurvisetus Mangin				r r	r r								r r
C. setoensis Ikari	r r				r r						r r		
C. socialis Lauder											c	c c	c c c
Biddulphia aurita (Lyngb.)					r r						r r		
B. longicruris Greville				c	c c								
B. sinensis Greville				r r	r r	r r		r r	r	r	c	c	r

	May 27, 1959.	June 18,	Aug. 29,	Sept. 21,	Sept. 29,	Oct. 14,	Nov. 5,	Nov. 16,	Dec. 1,	Dec. 11,	Jan. 13, 1960.	Jan. 29,	Feb. 17,
B. sp.				r r	r r								
Ditylum Brightwelli (West) Grunow				c	c				r		r r	r r	c
Hemiaulus sinensis Greville				r r	r r								
H. sp.					r r								
Triceratium gibbosum Bail						r	r	r	c c c	c			
Climacodium Frauenfeldianum Grunow								r r	r r				
Eucampia zoodiacus Ehrenberg											c c	c c	c c
Streptotheca indica Karsten			r r		r						r r		
S. thamensis Schrubsoll						r r							
Asterionella japonica Cleve					r r								
A. sp.											r r	r r	r r
Thalassoinema nitzschioides Grunow	r r			c	c	r					r	r	r r
Thalassiothrix Frauenteldii Grunow	r r			c	c					r	r	r	r
Th. longissima Cleve & Grunow				c	c								
Pleurosigma spp.											r		r r
Nitzschia paradoxa Gmelin					r						r r		
N. seriata Cleve	c				r							r	
N. spp.				r r	r r					r r	c c	c c	c c
Navicula sp.												r r	r r
MASTIGOPHORA													
Noctiluca scintillans Macartney	c c	r r	r r	r r		r r						r	c c
Pyrocystis noctiluca Murray	r r	r r	c c	c c		r	r r	r r	r r	r r			
Ceratium axialle Kofoid						r r							
C. bucephalum (Cleve)		r r											
C. candelabrum (Ehrenberg) Stein		r r											
C. deflexum (Kofoid) Jörgensen			r r	r r	r r	r r	r r						
C. fusus (Ehrenberg) Dujardin	r r	r r								r r			
C. intermedium (Jörg.) Jörgensen			r r										
C. lineatum (Ehrenberg) Cleve	r r												
C. macroceros (Ehrenberg) Cleve	r r					r r	r r	r	r r				
C. massirions (Gourret) Jörgensen	r r	r	r	r r		r	r	r	r r				
C. tenue var. buceros (Zacharias) Jörgensen							r r						
C. trichoceros (Ehrenberg) Kofoid		r r	r r	r r	r r	r	r	r					
C. tripos (O. F. Müller) Nitsch.	r r	r r			r r	r r		r		r r			
Dinophysis homuncclus Stein						r r							

	May 27, 1959.	June 18,	Aug. 29,	Sept. 21,	Sept. 29,	Oct. 14,	Nov. 5,	Nov. 16,	Dec. 1,	Dec. 11,	Jan. 13, 1960.	Jan. 29,	Feb. 17,
Peridinium conicum (Gran) Ostenfeld & Schmidt	r r												
P. depressum Bailey		r r											
P. divergens Ehrenberg						r r		r r					
P. oceanicum Vanhoffen					r r	r r		r r					
P. pellucidum (Bergh) (Schütt)		r r											
SARCODINA													
Globigerina bulloides D'Orbigny			r r	r r									
Acanthometron pellucidum (J'Müller)							r r	r r	r r	r r	r r		
Aulacantha scolimantha Haeckel				r r									
Aulosphaera cruciata Haeckel													
Dromosphaera polygonalis Haeckel					r r	r r			r r	c c	r r	r	r r
Hexalonche sp.					r r								
Sphaerozoum geminatum Haeckel								r r	r r		r r		
Staurosphaera sp.			c										
CILIOPHORA													
Tintinnopsis radix (Imhof)					r r								
T. sp.				r r	r r					r r			
HYDROZOA													
Obelia sp.	r r	r r	r r									r r	
Liriope tetraphylla Chamisso et Eysenhardt			r r					r r	r r				
Scolionema gemmifera Kishinouye											r r		r r
Aglaura hemistoma Peron et Lesueur					r r								
Abyla trigona Quoy et Gaimard					r r								
A. sp.			r r										
Abylopsis eschscholtzi (Huley)					r r								
A. tetragona (Otto)										r r			
Diphyes bojani (Eschscholtz)				r r									
D. chamissonis Huxley							r r	r r					
D. disper Chamisso et Eysenhardt			r	r r	r	r r				r r		r r	
D. spp.	r r	r	r	r r		r r	r	r r	r r	r r	r r	r r	
Muggiaea atlantica Cunningham	r r		r r	r r			r r				r r		r r
Porpita umbella O. F. Müller								r r					
Bolinopsis mikado (Moser)							r r		r r				
CHAETOPODA													
Tomopteris pacifica Izuka											r r		

	May 27, 1959.	June 18,	Aug. 29,	Sept. 21,	Sept. 29,	Oct. 14,	Nov. 5,	Nov. 16,	Dec. 1,	Dec. 11,	Jan. 13, 1960.	Jan. 29,	Feb. 17,
CHAETOGNATHA													
Pterosagitta draco (Krohn)									rr	rr			
Sagitta bedoti Beraneck	r	r	r	c	rr	rr		c	c	rr	rr	rr	rr
S. bipunctata Quoy et Gaimard	rr												
S. enflata Grassi	rr		cc	c	cc	r	ccc	ccc	ccc	ccc	rr	rr	rr
S. minima Grassi			rr		rr		rr	rr					
S. neglecta Aida					rr		rr	rr					
S. pulchra Doncaster								rr	rr	rr	rr		rr
S. robsta Doncaster			r							r			
S. serratodentata Krohn										rr			
S. sp.				rr	rr			rr			rr		
GASTROPODA													
Ianthina umbilicata D'Orbigny				rr									
Atlanta lesueuri Souleyet			rr	rr				rr	rr	rr			
Cavolina quadridentata (Lesueura)								rr	rr	rr			
Creseis acicula acicula Rang				rr	rr	rr	r	c	rr	rr			
C. virgula conica (Eschscholtz)			rr					rr	rr				
C. virgula virgula Rang								rr					
Limacia sp.								cc	cc	cc	r	rr	
CRUSTACEA													
Evadne nordmanni Lovén	r												
E. tergestina Claus	c		c	c									
Penilia schmackeri Richard	ccc	ccc	ccc	c	c	rr		rr					
Podon leuckarti G. O. Sars	c	rr		rr									
P. polyphemoides (Leuckart)	rr												
Conchoecia sp.			rr						rr	rr	cc		
Cypridina sp.							c	rr					
Calanus helgolandicus (Claus)	rr	rr								rr	rr	r	cc
C. minor (Claus)								c	c	r			
C. pauper (Giesbrecht)								r	rr				
C. darwini (Lubbock)			c	r	rr	rr	rr	c	c	c	rr		
C. vulgaris (Dana)			rr	ccc			rr	cc	rr	rr			
Eucalanus attenuatus (Dana)			rr					rr	rr	rr			
E. crassus Giesbrecht								rr	rr	c	rr	rr	r
E. elongatus Dana					rr					r			

	May 27, 1959.	June 18,	Aug. 29,	Sept. 21,	Sept. 29,	Oct. 14,	Nov. 5,	Nov. 16,	Dec. 1,	Dec. 11,	Jan. 13, 1960.	Jan. 29,	Feb. 17,
E. mucronatus Giesbrecht					r r	r r		r r		r r	r r		
E. pileatus Giesbrecht			c c	c c	r r	c	r	r	r r	r r			
E. subcrassus Giesbrecht					r		r r	r r		r			
E. subtenuis Giesbrecht					r r		r r	r r	r r	c c	r r		r r
Rhincalanus cornatus Dana								r r	r r	r r	r r		
Microcalanids	c c	c c	c	c	r		c	c	c	r r	r	r r	r r
Calocalanus pavo (Dana)			r	r r									
C. pulmulosus (Claus)			r r	r r				r r					
Aetidiopsis sp.										r r			
Undinopsis angustus Tanaka										r r	r r		
Euchaeta concinna Dana								r r		r r			
E. longicornis Giesbrecht										r r			
E. marina Prestendrea								r r	c	c	r	r r	
E. plana Mori								r r	r r				
E. wolfendeni A. Scott										r r			
Pareuchaeta resselli (Farran)							r r	r	c c	c c			
E. sp.							r r	r r					
Scolecithrix danae (Lubbock)								r r	r r	r r	r r		
S. sp.										r r			
Centropages abdominalis Sato											r r		
C. calaninus (Dana)			r r	r			r r						
C. furcatus (Dana)			c	c	c	c	c	c	r r	r r			
C. gracilis (Dana)								r r					
Temora discaudata Giesbrecht	r r		r	c			r r	r	r r	r r			
T. stylifera (Dana)			r	c			r r	r r	r r				
T. turbinata (Dana)							r r	r					
Pleuromamma gracilis (Claus)			r										
P. robusta Giesbrecht										r r	r r		
Heterorhabdus papilliger (Claus)										r r r			
Candacia bipinnata (Giesbrecht)										r r			
Candacia bradyi A. Scott			r r	r r				r r					
C. catula (Giesbrecht)			r	r r			r r	r r					
C. curta (Giesbrecht)		r r							r r	r r	r r		
Calanopia elliptica (Dana)			r r					r	r r	r r	r r		
Labidocera acuta (Dana)				r	r r	c	r	c	r				

	May 27, 1959.	June 18,	Aug. 29,	Sept. 21,	Sept. 29,	Oct. 14,	Nov. 5,	Nov. 16,	Dec. 1,	Dec. 11,	Jan. 13, 1960.	Jan. 29,	Feb. 17,
L. bipinnata Tanaka													
L. japonica Mori			r r										
Pontella chierchiae Giesbrecht							r r			r r r			
Pontellopsis sp.										r r r			
Pontellina plumata (Dana)						r r							
Acartia clausi Giesbrecht	c	r											
A. danae Giesbrecht			r r	r r			r r						
A. erythraea Giesbrecht			r			r r				r r			
A. hamata Mori				r r	r r			r r	r r				
A. negligens Dana			r r	r r									
A. pacifica Steuer					r r			r r	r r				
A. sp.			r r										
Tortanus forcipatus Giesbrecht			r r	r r	r r	r r	r	r r	r r				
Macrosetella gracilis (Dana)			r r	r			r r						
Euterpina acutifrons (Dana)	r		r r			r							
Oithona plumifera Baird			c	c	c	r	r r		r	r r	r r	r r	r r
O. similis Claus	c	r	r r										
O. sp.				r r									
Oncaea media Giesbrecht						r r			r				
O. venusta Philippi		r r	r r	c	r	r		r	r r	r r		r r	
Copilia mirabilis Dana					r			r r					
Corycaeus affinis McMurrich	r	r	r r					r r		r r	r r	r r	
C. clausi F. Dahl								r r					
C. crassiusculus Dana			r	r r	r r			r		r r		r r	
C. longistylis Dana					r r								
C. pacificus F. Dahl			r r	r	r r	r r		r	r r	r r			
C. speciosus Dana				r r			r r	c	c		r r	r r	
C. sp.			r	r r		r r	r r		r r				
Sapphirina angusta Dana								r r					
Hyperia sp.					r r		r r	r r	r r	r r	r r		
Euphausia sp.									r	r r	r r		
Lucifer typus Milne Edwards			r	r r	c c	c c	c c c	c	r r	r r	r r		
UROCHORDATA													
Fritillaria pellucida (Busch)	r r												
Oikopleura dioica Fol	r r			r r									r r

	May 27, 1959.	June 18,	Aug. 29,	Sept. 21,	Sept. 29,	Oct. 14,	Nov. 5,	Nov. 16,	Dec. 1,	Dec. 11,	Jan. 13, 1960.	Jan. 29,	Feb. 17,
O. longicauda (Vogt)										r r			
O. rufescens Fol			r	c c	c	c	c c	c c	c	c c c	c	r r	
Stegosoma magnum (Langerhans)							r r	r r		r r			
Doliolum nationalis Borgert									r r	r r			
Iasis zonaria (Pallas)					r r								
Pegea confoederata (Fowler)				r r									
Salpa fusiformis Cuvier		r r	r r	r r			c c c			r r			
Thalia democratica (Forskål)			r	r r									
T. democratica var. orientalis Tokioka													
Larval plankton													
Polychaeta larva	r r	r r	r r	r r	r r		r r				r r		r
Syphonautes larva			r r	r r		r r			r r				r r
Lingula larva			r r		r	r r							
Gastropoda veliger											r r		
Pelecypoda veliger									r r				
Stomatopoda Alima larva				r r				r r	r r				
Anomura zoea larva (Porcellana larva)				r r	r r		r r						
Macrura Pyllosoma			r r	r r	r r			r r					
M. mysis larva	r r	r	c	r r	c	r r	c c	c c c	r	r	r	r r	r r
Brachyura zoea larva	r r	r r	r	r	r	r r	c c c	r	r	r r	r r	r r	r r
Cirripedia nauplius larva	c	r									r r	r r	
C. cypris larva	r r	r		r r									
Ophiopluteus larva	r r		r r	r r	r	r r	r r	r r	c	c c	r r	r r	r r
Echinopluteus larva	r r				r r								r r
Fish egg	r r	r	r	r	r r	r r	r r	r r					
Fish larvae	r r	r r	r r	r r	r r		r r	r r					

Table 3–(1). Hydrographic Conditions in the Neighboring Waters

St.	Locality	Depth (m)	Atm. temp. (°C)	Water temp. (°C)	Cloudiness	Color (Forel)	Transparency	Cl (‰)	O_2 (cc/L)	$KMnO_4$ (ppm)	P (μg/L)
1	Kuro-Sima, S.	0	21.10	20.40	6	4	12.0	18.81		165.0	2.4
		10		20.00				18.86	5.35		
		20		19.22					5.13		
		30		18.78				18.90	5.45		
2	Kamikare-ki-Sima, NW.	0	20.80	20.40	3	4	11.4	18.85	5.85	168.8	0.4
		10		19.60				18.84	6.09		
		20		19.93				18.90	6.33		
		30		19.20				18.88	5.47		
3	Kikatu	0	21.50	22.20	2			18.90		162.3	0.8
		2									
		3									
4	„	0	22.10	20.80	2				6.59	178.8	1.6
		2									
		5									
5	„	0									
6	„	1									
7	„	0	23.10	21.63	2			18.83	6.15	166.0	1.6
		1									
		3									
		5									
8	Hoki	0	21.40	20.80	1	5					
		1		20.60				18.85	5.66	167.0	0.8
		2									
9	„	0	21.40	22.60	1	4	9.4	18.60	5.77		
		10		19.60				18.88	6.25		
10	Kawati	0	20.00	19.80	3	5	11.2	18.88	5.69	165.8	1.2
		10		19.30				18.91	5.89		
11	Sirahama	0	19.40	19.80	2			18.97	5.58	166.8	1.6
		2		19.30							
12	Usuka	0	22.00	20.50	2	4	14.8	19.06	5.98	187.0	1.6
		10		18.80							
13	Furue	0	22.60	21.20	1	4	14.0	19.00	5.69	155.0	1.6
		5						19.04	5.96		
		10		18.80							

of Hirado L., Northwestern Kyushu, in June 1959. (VI, 1–4)

SiO_2 (μg/L)	NO_2 (μg/L)	NO_3 (μg/L)	Turbidity	Mud (Org. C:%)	Grain-composition of Mud (%)						Remarks
					1	2	3	4	5	6	
62	Trace	0.20	0.049								
62	Trace	0.22	0.040								
30	Trace			3.10	2.00	16.25	18.00	24.00	5.60	34.15	
30	Trace	0.22	0.117	2.47	2.00	5.60	6.00	50.25	20.00	16.00	
			0.117		20.60	30.00	13.80	25.20	5.20	5.20	
62	0.8	0.20		1.55							
62	Trace	0.20		1.23	4.50	8.50	24.50	32.00	19.05	11.00	
			0.071		6.75	7.50	16.50	27.75	17.50	24.00	
30	Trace	0.23	0.034	0.76	1.75	7.50	8.00	50.38	18.75	12.50	
30	Trace	0.10	0.058	0.85	0	0.75	1.25	62.50	31.25	4.25	
				0.51	0	1.25	0.75	80.00	12.75	5.25	
				0.44	0	0.50	1.25	75.75	12.25	10.25	
Trace	Trace	0.22	0.038	0.93	12.10	36.28	13.95	23.26	12.55	1.86	
30	Trace	0.30	0.052	2.28	0	24.67	12.67	17.33	12.67	32.67	

Table 3–(1). Hydrographic Conditions in the Neighboring Waters of

St.	Locality	Depth (m)	Atm. temp. (°C)	Water temp. (°C)	Cloudiness	Color (Forel)	Transparency	Cl (‰)	O_2 (cc/L)	$KMnO_4$ (ppm)	P (μg/L)
14	Furue	0 5									
15	„	0 10									
16	„	0 1 3 8									
17	Nakae-Sima, E.	0 10 20 30	20.90	19.80	2	4	17.0	19.08 19.04 19.06 19.07	5.73 5.71 5.67 5.60	260.8	2.0
18	Nesiko	0 2	20.40	19.50 19.30	2			19.05	5.79	160.0	1.6
19	Tateba-Sima, W.	0 10 20 30	20.40	19.70 18.50 18.81 18.63	3	3	21.0	19.09 19.09 19.12 19.09	5.43 5.97 5.33 5.90	178.0	1.6
20	Ira	0 1 2	20.60	19.90 19.30	3			18.96		16.05	1.6
21	Itoya	0 2 5	23.40	21.50 20.50	3			19.03	5.73	182.8	3.2
22	Wakamiya	0 1	22.20	22,60 21.90	3			18.64	5.81	175.8	3.2
23	Kota	0 1	21.80	23.30 23.30	4			17.84	6.41	155.0	4.6
24	Sisiki	0 10	21.60								
25	Sisiki, S.	0 10 20 30	21.10	20.40 20.00 19.22 18.78	6	4	12.0	18.81 18.86 18.90	 5.35 5.13 5.45	165.0	2.4

Hirado L., Northwestern Kyushu, in June 1959. (VI. 1–4) (continued)

SiO_2 (μg/L)	NO_2 (μg/L)	NO_3 (μg/L)	Turbidity	Mud (Org. C:%)	Grain-composition of Mud (%)						Remarks
					1	2	3	4	5	6	
Trace	Trace	0.20	0.030								
30	Trace	0.24	0.085	0.42	0	0.60	16.20	76.20	1.80	5.20	
Trace	Trace	0.30	0.034								
30	Trace	0.30	0.070	0.19	0	0.50	5.75	78.00	4.75	11.00	
62	Trace	0.24	0.129	1.03	1.00	7.75	4.75	52.00	12.50	22.00	
Trace	Trace	0.20	0.088	0.41 0.82 4.76	8.75 8.50 6.50	25.25 36.75 15.50	24.25 17.50 14.25	9.50 26.50 29.25	0.25 6.25 10.00	32.00 4.50 24.50	
90	0.2	0.10	0.126	1.36	21.55	39.55	11.11	8.00	2.22	17.56	
			0.052		0	1.75	3.50	56.25	27.25	11.25	
60	Trace	0.20	0.049								

Table 3-(2). Hydrographic Conditions in the Neighboring Waters

St.	Locality	Depth (m)	Atm. temp. (°C)	Water temp. (°C)	Cloudiness	Color (Forel)	Transparency	Cl (‰)	O_2 (cc/L)	$KMnO_4$ (ppm)	P (μg/L)
1	Kuro-Sima, S.	0 10 20 30									
2	Kamikare-ki-Sima, NW.	0 10 20 30	24.20	24.80 24.70 25.20 24.41	8			18.80 18.79 18.85 18.88	4.5 4.4 4.4 4.2	152.94	2.0
3	Kikatu	0 2 3	26.60	28.10 27.60	5			18.29 18.47	5.0 4.9	139.67	0.8
4	„	0 2 5	26.40	27.20 25.40		6		18.54 18.76	4.5 4.4	137.14	2.0
5	„	0									
6	„	1									
7	„	0 1 2 5	27.30	27.10	5	9		18.72 18.72	5.3 5.1	163.69	2.4
8	Hoki	0 1 2	26.90	26.40 25.90	3			18.79 18.79	4.6 4.5	151.05	2.4
9	„	0 10	26.80	26.10 25.10	3	5	7.5	18.10 18.77	4.6 4.4	139.04	4.0
10	Kawati	0 10	26.10	25.10 24.70	3	5	5.0	18.80 18.79	4.6 4.5	152.31	2.0
11	Sirahama	0 2		24.00 23.80		5	3.0	18.87 18.84	4.8 4.6	135.25	1.2
12	Usuka	0 10	25.80	24.80 23.40	3	5	7.2	18.85 18.88	4.8 4.9	145.36	2.4
13	Furue	0 5 10	26.50	27.80 24.60 24.70	2	6	5.3	18.52 18.82 18.76	4.9 5.0 4.6	141.63	1.6

of Hirado I., Northwestern Kyushu, in August 1959. (VIII, 10–13)

SiO_2 (μg/L)	NO_2 (μg/L)	NO_3 (μg/L)	Turbidity	Mud (Org. C:%)	Grain-composition of Mud (%)						Remarks
					1	2	3	4	5	6	
30			0.040								
62	Trace		0.099	1.28	24.17	29.17	9.17	27.00	4.67	5.82	
30			0.050		9.67	6.50	2.83	11.33	27.00	46.67	
30			0.093	0.95	0	23.00	12.67	10.83	16.67	36.83	
30	Trace		0.058	1.70	4.00	14.17	15.00	48.17	9.50	9.16	
45			0.103	1.36	16.00	22.83	7.67	27.50	13.67	12.33	
30			0.052	1.07	6.00	8.60	11.00	27.00	37.60	9.80	
62			0.055	0.30	1.86	2.86	0.86	75.00	17.14	2.28	
30			0.060	0.28	5.17	51.50	16.83	24.67	1.50	0.33	
30			0.040		6.67	4.17	3.33	7.50	30.83	47.50	

Table 3–(2). Hydrographic Conditions in the Neighboring Waters of

St.	Locality	Depth (m)	Atm. temp. (°C)	Water temp. (°C)	Cloudiness	Color (Forel)	Transparency	Cl (‰)	O_2 (cc/L)	$KMnO_4$ (ppm)	P (μg/L)
14	Furue	0	25.70	26.80	2	6		18.56	4.6	143.46	2.4
		5		25.20				18.76	4.9		
15	„	0	25.80	25.80	2	5	6.3	18.68	4.7	139.67	3.2
		10		23.70				18.87	4.9		
16	„	0	25.40	26.90	2	5	5.5	18.63	4.5	151.05	3.6
		1									
		3		24.90				18.82	4.8		
		8		23.60				18.89	4.9		
17	Nakae-Sima, E.	0	26.20	24.40	3			18.89	5.0	149.15	4.6
		10		23.80				18.92	5.0		
		20		24.06				18.89	4.9		
		30		23.01				18.92	4.9		
18	Nesiko	0	26.80	24.40	3			18.87	4.9	151.68	1.2
		2		24.40				18.86	4.9		
19	Tateba-Sima, W.	0	25.50	24.20		4	12.0	18.86	4.7	145.99	1.0
		10		23.80				18.87	4.8		
		20		23.94				18.86	4.9		
		30		23.99				18.93	4.6		
20	Ira	0	26.10	24.40				18.77	4.8	154.84	2.8
		1									
		2		24.20				18.83	4.6		
21	Itoya	0	27.80	25.80				18.64	5.4	143.46	1.6
		2									
		5		24.80				18.81	5.1		
22	Wakamiya	0	28.90	28.00		8		18.06	6.0	146.62	1.6
		1		27.00				18.44	6.6		
23	Kota	0	27.80	27.90				17.90	5.0	139.04	1.6
		1		27.60				18.33	5.6		
24	Sisiki	0	25.61	25.80	2	7	3.5	18.82	4.8	145.36	2.4
		10		23.60				18.91	4.8		
25	Sisiki, S.	0	25.60	25.80		4	9.5	18.77		152.31	1.6
		10		24.40				18.82			
		20		24.40				18.94			
		30		22.36				18.98			

Hirado I., Northwestern Kyushu, in August 1959. (VIII, 10–13) (continued)

SiO_2 (μg/L)	NO_2 (μg/L)	NO_3 (μg/L)	Turbidity	Mud (Org. C:%)	Grain-composition of Mud (%)						Remarks
					1	2	3	4	5	6	
30			0.040		35.00	28.50	9.67	16.67	6.50	3.66	
45			0.048	2.18	13.30	19.33	2.67	21.00	19.67	24.50	
30			0.020		8.83	30.83	18.33	17.67	14.50	9.84	
30			0.030								
100			0.042	0.53	0	0.83	11.17	85.67	1.33	0.10	
45			0.045								
30			0.052	0.33	0	0.67	6.50	85.83	4.00	3.00	
80			0.042	0.80	0.33	5.00	6.33	73.33	2.83	12.18	
125			0.090	1.73	22.00	18.17	13.50	27.83	7.50	11.00	
30			0.250	4.40	31.25	16.25	6.25	20.00	11.50	14.75	
80	Trace		0.060	0.67	0.50	1.50	1.50	70.33	19.33	6.84	
45	Trace		0.030								

Table 3–(3). Hydrographic Conditions in the Neighboring Waters of

St.	Locality	Depth (m)	Atm. temp. (°C)	Water temp. (°C)	Cloudiness	Color (Forel)	Transparency	Cl (‰)	O_2 (cc/L)	$KMnO_4$ (ppm)	P (μg/L)
1	Kuro-Sima, S.	0	22.00	18.60	0.5	7	16.0	19.11	5.2	209.75	2.8
		10		18.80				19.19	5.6		
		20		18.61				19.20	5.2		
		30		18.60				19.22	5.0		
2	Kamikare-ki-Sima, NW.	0	14.30	16.90	10	5	10.8	19.14	5.1	179.49	2.5
		10		18.67				19.14	5.3		
		20		18.63				19.16	5.3		
		30		18.49				19.19	5.2		
3	Kikatu	0									
		2									
		3									
4	„	0	16.20	15.50	10			17.87		189.60	6.2
		2									
		5									
5	„	0	15.60	13.30	10			7.21	3.8	151.68	1.4
6	„	1	15.70	15.90	10			17.20	4.5	209.85	15.0
7	„	0	16.80	15.40	10	8	5.5	15.96	5.1	210.52	1.3
		1									
		2									
		5		17.00				19.00	5.4		
8	Hoki	0	12.00	17.40	10	6		19.00	5.7	209.75	2.8
		1									
		2		17.50				19.00	5.6		
9	„	0	12.20	17.80	10	6	8.1	19.14	5.5	213.65	0.5
		10		17.92				19.15	5.5		
10	Kawati	0	11.20	17.20	10	5	8.5	19.04	5.6	194.65	2.8
		10		17.91				19.10	5.9		
11	Sirahama	0	10.00	17.20		5		19.14	5.9	190.08	0.5
		2		17.40				19.14	5.2		
12	Usuka	0	11.00	17.90		4	11.0	19.15	5.5	190.08	2.0
		10		18.00				19.17	5.4		
13	Furue	0	12.40	16.90		5	8.5	19.03	5.5		
		5									
		10		16.80				19.06	5.4		

Table 3-(1). Hydrographic Conditions in the Neighboring Waters

SiO_2 ($\mu g/L$)	NO_2 ($\mu g/L$)	NO_3 ($\mu g/L$)	Turbidity	Mud (Org. C:%)	Grain-composition of Mud (%)						Remarks
					1	2	3	4	5	6	
40		Trace	0.028								
30	4.0	Trace	0.104								
100	1.0	2.0			13.40	17.60	20.00	29.00	4.80	25.20	
250		Trace		1.98	19.70	26.50	20.50	19.10	5.50	8.70	
175		0.5		1.47							
150		Trace	0.090	1.62	1.33	7.73	17.60	28.67	8.00	36.67	
40		Trace	0.032	2.41	10.20	13.00	21.00	28.00	9.00	18.80	
40	5.0	Trace	0.076	0.61	8.50	11.50	6.00	17.20	26.00	30.80	
30	1.0	Trace	0.064	1.18	7.50	20.00	17.50	25.83	15.83	13.34	
30	Trace	0.5	0.064	0.43	0.40	10.20	25.00	36.00	11.00	17.40	
25	5.0	Trace	0.024	0.93	13.83	34.00	20.83	19.33	5.83	6.18	
				1.80	1.00	0.67	1.83	13.50	29.83	53.17	

Table 3–(3). Hydrographic Conditions in the Neighboring Waters of Hirado I.,

St.	Locality	Depth (m)	Atm. temp. (°C)	Water temp. (°C)	Cloudiness	Color (Forel)	Transparency	Cl (‰)	O_2 (cc/L)	$KMnO_4$ (ppm)	P (μg/L)
14	Furue	0 5		16.60		5		19.10 19.14	5.6 6.5	227.52	1.0
15	„	0 10	11.00	16.90 17.20		5	9.0	19.14 19.17	5.4 5.3	187.57	1.0
16	„	0 1 3 8		12.00 16.30		5		19.20 19.20	5.5 5.9	230.31	1.0
17	Nakae-Sima, E.	0 10 20 30	13.00	18.00 18.00 18.00 18.00		4	13.0	19.14 19.15 19.15 19.16	5.6 5.5 4.4 5.2	246.48	1.4
18	Nesiko	0 2	11.00	17.70 17.50		5		19.16 19.19	5.3 5.4	233.84	0.5
19	Tateba-Sima, W.	0 10 20 30	11.20	17.90 18.00 18.00 18.00		4	12.0	19.15 19.17 19.19 19.20	5.1 6.4 6.2 5.2	242.69	1.3
20	Ira	0 1 2	10.00	17.40		6		19.07	5.2	225.34	1.0
21	Itoya	0 2 5	8.40			6		18.03	5.8	242.69	1.3
22	Wakamiya	0 1	8.00					19.16	6.4	190.08	0.5
23	Kota	0 1	9.40	11.70	10	9		15.52		230.03	1.5
24	Sisiki	0 10	9.60	14.70	10	5	9.0	19.14	5.5	237.00	1.4
25	Sisiki, S.	0 10 20 30									

Northwestern Kyushu, in December 1959. (XII, 9–10 & 18–20) (continued)

SiO_2 (μg/L)	NO_2 (μg/L)	NO_3 (μg/L)	Turbidity	Mud (Org. C:%)	Grain-composition of Mud (%)						Remarks
					1	2	3	4	5	6	
10	2.0	Trace		2.19	6.50	12.90	11.00	20.20	10.00	39.40	
10	1.0	Trace	0.046	2.16	0.17	0.50	1.83	9.17	11.17	77.16	
10	2.0	Trace	0.054	2.30	6.00	10.20	9.70	12.90	12.00	49.20	
30	4.0	2.0	0.010								
10	2.0	Trace	0.042	0.57	0	0.67	3.83	44.83	46.56	4.17	
10	1.0	Trace	0.040								
25	3.0	1.5	0.030	0.28	0	0.17	2.17	34.17	60.00	3.49	
75	Trace	Trace	0.040	0.36	0.50	3.67	5.67	21.50	32.50	36.16	
10	2.0	Trace	0.020	0.43	4.30	9.80	23.20	21.00	2.50	39.70	
100	Trace	0.5	0.258	0.50	10.50	52.00	16.00	6.20	1.90	13.40	
30	1.0	Trace	0.014	0.59	0.33	1.17	2.00	21.50	52.50	22.50	

Table 4-(1). Relative Abundance of Plankton Members in the

Station	1	2	4	7	8	10	11
ZOOPLANKTON							
Copepoda	r r	r r	r r	r r		r r	
Ceratium	r r	r r	r r	r r			r r
Peridinium		r r					
Noctiluca							
Favella		r r					
Dictyocha		r r			r r	r r	
Pyrophacus							r r
Tintinnopsis						r r	
Oikopleura	r r	r r		r r	r r		
PHYTOPLANKTON							
Chaetoceros	c c	c c	c c	c c	c c	c c	c c
Thalassionema	r r	r	r r	r r	r r	r r	r r
Thalassiothrix	r r	r r	r r	r r	r r	r r	r r
Bacteriastrum	r r	r	r r	r r	r r	r	r
Nitzschia		r r		r r	r r	r r	r r
Rhizosolenia	r r	r r		r r	r r	r r	
Lauderia	r r	r r			r r	r r	
Skeletonema	r r	r r					
Leptocylindrus							
Coscinodiscus					r r		
Ditylium		r r					
settling volume (ml)	66	57	167	23	72	129	55

Table 4-(2). Number of Plankton Cells in 1 l Sea Water in

Station	1	2	4	7	8	10	11
ZOOPLANKTON							
Copepoda							
Dinoflagellata		250		250	250		
Distephanus speculum		500		250			
Ceratium fusus							
C. kofoides		250					
PHYTOPLANKTON							
Chaetoceros	47750	28500	26500	12000	18250	39000	12000
Rhizosolenia	750				250	250	1500
Bacteriastrum	250				4250	1250	250
Skeletonema	2250	2750	2250			1750	
Thalassionema	750	250		1000		500	500
Thalassiothrix		500			250		
Nitzschia			250		750		750
Leptocylindrus		2000		2000	5500	2750	
Hemiaulus							
Cerataulina			750			750	
Dactyliosolen							
Melosira			250		2000		
Lauderia						250	250
Pleurosigma			250	250			
Gyrosigma							
Navicula			250	250			500
Amphiprora						250	250
Donkinia				250			
Cymbella							
Cocconeis							

Neighboring Waters of Hirado I., in June 1959. (VI, 1–4)

12	15	17	18	19	20	21	22	23	24
r r	r r	r r	r r			r r	r	r	r r
r r	r r	r r	r r	r r	r r	r r	r r	r r	r r
					r r				
r r	r r		r r					r r	
r r									
					r r	r r			
r r		r r	r r			r r	r r		
c c	c c	c c	c c	c c	c c	c c	c c	c c	c c
r	r	r r	r r	r r	r	r r			
r r	r r	r r	r r	—	r	r r	r r	r r	r r
r r	r r	—	r r	—	—	r	r r	r r	r
r r	r r	r r		r r	r r				
r r	r r	r r	r r	r r	r	r r		r r	r r
r r			r r	r r					
r r									
r									
			r r		r r	r r			
59	34	62	20	41	6	12	3.5	3.0	23

the Neighboring Waters of Hirado I., in June 1959. (VI, 1–4)

12	15	17	18	19	20	21	22	23	24
		250							
			2000	250		750	1250	1750	250
		250	750	250	500		1000		
					250				
123710	111500	18500	5250	4250	1750	2500	1500		3250
		1250	250		250				
			250						
							1750		1750
1000	2000								
500	500	500							
750	2000			500	1000			500	
	750		500						
	250								
250	250								
						1000			
								250	
								500	
		250					750	250	
							250		
								250	
								250	
						250		3500	

Table 4–(3). Number of Important Members of Larger Plankton Animal by a

Station	1		2		4	8	10	11
Depth (m)	0	20	0	20	0	0	0	0
Fish Egg	59	2	191		36	5	17	188
(Anchovy)	(6)							
Larvae		1			7			3
Crustacea								
Larvae	18	17	2	11	17	2	9	233
Copepoda	74	562	16	20	27		120	897
Amphipoda	33							250
Isopoda								4
Lucifer								
Conchoecia								
Sagitta		4		26				44
Annelida								
Oikopleura	15	165						
Pluteus	1	87						
Mollusca								
Gastropoda								
Others	1							

Horizontal Haul in the Neighboring Waters of Hirado I., in June 1959. (VI, 1–4)

12	15	17		18	19		20	21	22	23	24
0	0	0	20	0	0	20	0	0	0	0	0
13	20	23	3	1	16		32	14	21	29	35
2	3			1	2	2	9	12	1	6	1
20	26	39	1		61	14	164	183	14	13	25
146	166	96	26	991	453	140	156	236	38	130	77
47	17	14	2	6	4		2	1	10	349	31
2	1										
		2	1					9			
4		1									
	2	7	4	205	52	58	3	9			65
						21					
										1	

Table 5-(1). Relative Abundance of Plankton Members in the

Station	1	2	3	4	7	8	9	10	11
ZOOPLANKTON									
Copepoda	r r	r r	r	r r	r	r r	r r	r r	r r
Balanus nauplius			r r						
Phyllopoda							r r		
Ophiopluteus			r r		r r				
Polychaeta									
Ceratium	r r	r r	r r	r r	r r	r r	r r	r r	r r
Peridinium	r r		r r	r r			r r		r r
Favella									
Dictyocha	r r								r r
Pyrophacus		r r			r r				
Aulacantha		r r	r r	r r		r r	r r		
Tintinnopsis	r r	r r	r r	r r	r r	r r	r r	r r	r r
Tintinnus									r r
Oikopleura	r r	r r							
PHYTO-PLANKTON									
Coscinodiscus		r r					r r		r r
Thalassiosira								r r	
Lauderia		r r			r r	r r			r
Skeletonema	r r								
Stephanopyxis		r r		r r				r r	r r
Dactyliosolen	r r	r r			r r		r r		r r
Leptocylindrus	r r	r r		r r				r r	r r
Guinardia					r r			r r	r r
Rhizosolenia	r	r	r r	r r	r r	r	r	r	r
Bacteriastrum	c	c	+	c	c c	c c	c c	c c	c
Chaetoceros	c	c c	r	+	r	c	+	c c	c c
Biddulphia	r r	r r			r r			r r	r r
Hemiaulus	r r	r r							
Cerataulina		r r			r r		r r	r r	
Ditylum	r r	r r	r r	r r	r r	r r	r r	+	r
Eucampia	r r					r r			
Corethron		r r					r r		r r
Thalassiothrix	r	c c	r r	r	r	+	c	c	c
Thalassionema	+	c c	r r	r	r	+	c	c	c
Navicula	r r								r r
Pleurosigma	r r	r r		r r			r r	r r	r r
Amphiprora								r r	
Nitzschia	r r	r r		r r	r r	r r		r r	r r
settling volume (ml)	32	23	7	34	38	26	19	56	67

Neighboring Waters of Hirado I., in August 1959. (VIII, 10–13)

12	13	14	15	16	17	18	19	20	21	22	24
r r	r	r	r r	r r		r r	r r		r r	r	
									r r	r r	
	r r	r r									
			r r	r r		r r					
						r r				r r	
	r r	r r	r r	r r	r r	r r	r r	r r	r r	r r	
r r			r r			r r		r r		r r	
r r					r r						
	r r	r r	r r	r r	r r		r r	r r			
r r	r r	r r	r r	r r		r r	r r	r r	r r	r r	
										r r	
	r r										r r
	r r			r r			r r				
							r r				
r r					r	r r	r r	r r		r r	r r
r r								r r			
r r		r r	r r			r r	r r	r r			
				r r		r r	r r	r r			
						r r	r r	r r	r r		
+	r r	r r	+	r	r r	+	r	+	r r	r	r
c	c c	c c	c c	c	c c	c	c	c	c c	c	c
c c	c	c c	c	c	c c	c c	c c	c c	c c	c	c
r r			r r	r r	r r		r r				
		r r									
c	+	r	r	r	r r		+	+	r r	r r	r
r r											
r r			r r					r r			r r
c	c	r	+	c	c c	c	c	c	c	+	r
c c	+	+	c	c	c c	c c	c c	c c	+	r	+
r r				r r		r r	r r				
								r r			
r r											
					r r	r r	r r	r r	r r	r r	r r
64	36	72	91	37	25	130	92	55	22	17	29

Table 5-(2). Number of Plankton Cells in 1l Sea Water in the

Station	2	3	4	7	8	9	10	11
ZOOPLANKTON								
Copepoda						500		
Peridinium				250			250	
Ceratium fusus								
C. furca		250	250					
C. sp.								
Tintinnopsis aperta				250				
T. subacuta								
T. sp.								
Dictyocha fibula	250			500	500			
Parafavella					250			
Distephanus speculum	750						250	500
Amphorella bradti ?			250		250			
Radiolaria spp.							250	
PHYTOPLANKTON								
Skeletonema costatum				250				2750
Chaetoceros spp.	61500	11000	10750	16500	13250	13800	32000	77250
Bacteriastrum spp.	14500	9250	13750	10000	12250	19750	46250	38500
Rhizosolenia spp.	2000	1500	250		500		1000	500
Leptocylindrus	2750				2500	1000		2500
Dactyliosolen			250	250	250	250	500	1000
Ditylum spp.	750			750	250	250	500	500
Cerataulina	4750		250			250		250
Corethron								
Coscinodiscus			250					
Eucampia spp.	1250					250		250
Lauderia borealis								
Guinardia	1750							
Thalassiosira spp.								2750
Hemiaulus sinensis								
Climacodium								
Streptotheca thamensis								500
Melosira sulcata								
Thalassionema nitzschioides	28500	500	2750	10000	3750	3250	10500	17500
Thalassiothrix frauenfeldii	2250	250	1500	1000	1250	750	2500	5250
Nitzschia spp.	3750	500	250	1250	500	500	1750	2500
Pleurosigma spp.	250			250				
Licmophora								
Cocconeis spp.								
Cymatopleura solea								
Surirella norvegica								
Navicula spp.	250	500					250	
Amphiprora gigantea		250						
Asterionella japonica								2000
Amphora quadrata								

Neighboring Waters of Hirado I., in August 1959. (VIII, 10–13)

12	13	14	15	16	17	18	19	20	21	22	23	24	25
	250	500						500					
250													
250									250				
			250							750			
											500		
			250						500	500			
							500			750			
250			250				250					250	250
			250		250								
	13500				750		750	3750	1750			3500	250
68000	10000	23500	17000	3500	66750	67000	40750	64000	16750	8750	3250	36000	22250
13500	8500	12000	19500	3000	50250	23000	26000	16750	5000	3500	1000	17000	15000
2750	750	250	500		3500	5250	1000	1750	250	250		2000	27500
3250		1250	1000		6750	4750	1500	1250	250	500			
2500	750	500	750		500	1000	1500	250	750	500		250	1000
2000	1500	1000	1000	500	1750	500	500	1500	1000			500	
250		1750		250				250					1000
						250						750	250
							250						
1250					500	1750	1500	2500		1500			
						1000							
					2000	1500							
1500						500							
250													
								1500					
8750	750	500	4250	1250	7250	11750	15500	9250	4250	4500	1250	9750	4750
7000	250	500	500	750	3250	2000	500	5250	2500	500		4250	1500
2000					1500	5000	6000	3750	2500	500	2250	2750	1500
				250	250					500			250
											500		
								250			750		
							250						
							250						
								250					
						250							

Table 5-(3). Number of Important Members of Larger Plankton Animal

Station	2		4	7	8	9	10	11	12	13	14
Depth (m)	0	20	0	0	0	0	0	0	0	0	0
Fish Egg	79	78	38	190	60	79	47	12	64	152	104
(Anchovy)									(4)		
Larvae		11	3	2	7	3	5			15	6
Crustacea											
Larvae	343	26	25	6	14	6	42	4	8	330	291
Copepoda	313	241	348	67	25	85	118	11	44	1495	704
Amphipoda		1					1	1			
Isopoda											
Lucifer											
Conchoecia											
Sagitta	14	200	53	5	11	17	23	9	9	106	23
Annelida											
Oikopleura	11	14	4		1	42	34		17	11	1
Pluteus											
Mollusca											
Gustropoda											
Others											

by a Horizontal Haul in the Neighboring Waters of Hirado I., in August 1959.

(VIII, 10–13)

15	16	17		18	19		20	21	22	23	24	25	
0	0	0	20	0	0	20	0	0	0	0	0	0	20
103	28	72	26	109	79	59	44	291	45	2	113	98	610
	(1)	(2)			(1)								
1	1	10	11		2		1	1			2	1	2
13	34	12	41	20	1	48	3	8	48	1	10	9	66
132	189	61	168	28	43	112	53	2	38	6	100	253	142
								1					2
14	6	9	512	22	60	296	85	1	19	289	120	540	211
	2	118	110	2	101	237	46	1	3	1	3	138	13

Table 6-(1). Relative Abundance of Plankton Members

Station	2	6~7	8	9	10	11
ZOOPLANKTON						
Copepoda	r r	r r	r r	r r	r r	
Ceratium	r r	r r	r r	r r	r r	
Peridinium	r r	r r		r r	r r	
Favella		r r	r r			
Aulacantha						
Acanthometron				r r		
Tintinnopsis					r r	
Pyrocystis		r r				
Dinophysis		r r				
Oikopleura	r r	r r	r r	r r		
Atlantha						
PHYTOPLANKTON						
Melosira		r r				
Coscinodiscus	r r	r r	r r	r r	r r	
Hemidiscus		r r	r r		r r	
Thalassiosira	+	r r	r r	r	r r	
Lauderia	+	r	+	r r	r r	
Schroedella	r r				r r	
Stephanopyxis	r	r	r r	r	r	
Dactyliosolen	r r	r r		r r	r	
Leptocylindrus			r r		r r	
Guinardia	r r	r r		r r	r r	
Corethron	r r		r r			
Rhizosolenia	+	+	+	+	+	
Bacteriastrum	r	+	+	r r	r	
Chaetoceros	c	c	c c	c c	+	
Biddulphia	+	+	+	+	r	
Hemiaulus	r r	r r	r r		r r	
Cerataulina	r r	r r	r r			
Ditylum		r r	r r	r r	r r	
Climacodium					r r	
Streptotheca				r r		
Eucampia	+		+	r r	r r	
Planktoniella	r r					
Asterionella				r r	r r	
Thalassionema				r r		
Thalassiothrix	r r	r r	r	r r	r r	r r
Licmophora						r r
Pleurosigma		r r	r r	r r	r r	r r
Nitzschia	r	r r	r r	r r	r r	r r
Gyrosigma						
settling volume(ml)	27	51	152	125	23	42

in the Neighboring Waters Hirado I., in December 1959

(XII, 9–10 & 18–20)

12	15	16	17	18	19	20	21	22	24
r r	r r	r r	r r	r r	r r	r r	c c	r	r r
r r						r r	r r	r r	r r
r r						r r	r r	r r	r r
						r r	r r	r r	
								r r	r r
						r r	r r		
							r r	r r	
r r						r r			
r r						r r	r r		r r
r r	r r	r r	r r	r r	r r			r r	r r
r r						r r	r r		
r r	r r		r r	r r		r r	r r		
r r	r r		r r	r r	r r	r r	r r	r r	r r
r r	r r	r	r r	r r	r r	r r		r r	r r
r r	r r	c	+	r r	r	r r	r r	r r	r r
r r	r r	r r	r r	r r	r r	r r		r r	r r
	r r								
r	r r	r r	+	r r	r	r r	r r	r r	r
r r	r r		r r	r r	r r	r r		r r	r r
	r r					r r		r r	
			r r	r r	r r			r r	r r
r r	r r		r r	r r	r r			r r	r r
+	+	r r	+	+	+	r	r r	r	+
r r	r r	r r	r r	r r	r r	r r	r r	r r	r r
+	r r	r r	r	r	+	r	r r	+	+
r	+	r r	r	+	r	r	r r	r r	r r
r r	r r		r r	r r	r r	r r		r r	r r
	r r		r r	r r	r r				
r r	r r		r r	r r	r r	r r	r r	r r	r r
r r			r r	r r		r r		r r	
r r			r r	r r	c	r r		r r	r r
+	+	r r	+	c	r r	+	r	c	r
	r r			r r	r r				
	r r		r r						
		r r	r r	r r		r r	r r	r r	r r
	r r		r r	r r	r r	r r		r r	r r
							r r		r r
	r r		r r	r r	r r	r r	r r	r r	r r
	r r		r r	r r	r r	r r			r r
			r r				r r		r r
42	10	5	33	36	30	9	6	44	58

Table 6-(2). Number of Plankton Cells in 1l Sea Water in the

Station	1	2	7	8	9	10	11
ZOOPLANKTON							
Copepoda							
Ceratium fusus							
C. furca							
C. tripos							
Peridinium						250	
Distephanus speculum	500	500		250	250		
Goniaulax sp.							
Dictyocha fibula				500			
PHYTOPLANKTON							
Skeletonema costatum		3750					
Chaetoceros socialis	112500	35500	112750	268250	394750	149000	30250
C. decipiens					1750	2500	
C. curvisetus			1750	1750	3000	2750	
C. lorenzianus			250				
C. eibeni			500	1500		150	
C. brevis			1500	1500	1000		
C. didymus				2250	1000		
C. tortissimus			2500	2250			
C. previanus					250		
C. affinis					2750	6500	
C. spp.		1750	13750	5250	15500	2500	
Rhizosolenia stolterfothii		1500	3750	4000	8250	7750	3250
R. styliformis							750
R. setigera			250		250		250
R. carcaravis							250
R. delicatula		2000	250			2250	
Guinardia flaccida							
Thalassiosira subtilis	8250	39750	750	26750	1750	60750	
T. condensata			750	1000	1000	2000	
T. sp.							
Coscinodiscus						500	
Actinoptychus							
Melosira							
Eucampia zoodiacus							
Asteromphalus							
Ditylum brightwellii							
Lauderia borealis		250	250	2250	1000	1000	750
Biddulphia sinensis			250		250	250	
Corethron pelagicum				250	250		
Bacteriastrum varians		250			1750	250	
B. mediterraneum			2250		3000		
Hemiaulus sinensis					1250		
Climacodium biconcavum						250	
Thalassionema nitzschioides		1500	4000	3750	3500		500
Nitzschia closterium							
N. seriata	1000			750	750	750	
N. longissima	4750			1250	750	750	
Diphoneis sp.							
Amphiprora							
Grammatophora marina							
Licmophora							
Cocconeis scutellum							
C. sp.		250					
Pleurosigma affine	250	500		3750		500	250
P. sp.							
Asterionella japonica				2500			8000
Gyrosigma	250						

Neighboring Waters of Hirado I., in December 1959. (XII, 9–10 & 18–20)

12	14	15	16	17	18	19	20	21	22	23	24
	500	250							250		
										250	
			250		500						
							250				
				250					250		
			1250								
	250										
4250	1250	4250	11750	4500	22000	6000	12750		4000		2000
3750					500				1750		
2500									12000		
						1500					
				250	1250	750					
			1250								
		500		750		3500		250	1500		750
750	2750	4500	2500	1000	1000	1250	7000	250	500	250	250
				500							
	3750	250	750			500					500
	500			1000	1750						
750			250	1750		1000					
	250	250	250	250					250		250
250											
										500	
					750		250		4000	250	3500
	250										250
	250										2500
	250										
											2750
	750			1000							500
					250						
					250						500
	250	250	250			250					500
				250						250	
										250	
										250	
									250	750	
										250	
										1000	
					250	250					
										250	
		250									

Table 6-(3). Number of Important Members of Larger Plankton in December 1959. (XII, 9-10 & 18-20)

Station	1		2		6~7		8	9
Depth(m)	0	20	0	20	0	0	0	0
Fish Egg	13	6	9		1			2
(Anchovy)	(4)	(2)	(5)				(5)	
Larvae		7		1				
Crustacea								
Larvae	26	85	65	30			5	2
Copepoda	499	279	203	113	62		11	25
Amphipoda	1							
Isopoda								
Lucifer								
Conchoecia								
Sagitta	90	96	61	10	72		3	2
Annelida								
Oikopleura	513	279	256	41	9			
Pluteus								
Mollusca								
Gastropoda								
Others		1					5	1

Table 7. Monthly Value of E_{435} and E_{670}. Brackets show the collection number

	E_{435}	E_{670}
Apr.	0.189 (8)	0.065 (7)
May	0.248 (22)	0.082 (22)
June	0.249 (22)	0.073 (22)
July	0.412 (18)	0.141 (18)
Aug.	0.113 (3)	0.027 (3)
Sept.	0.122 (7)	0.040 (7)
Oct.	0.108 (7)	0.036 (7)
Nov.	0.175 (6)	0.048 (6)
Dec.	0.154 (9)	0.045 (9)
Jan.	0.170 (8)	0.059 (8)
Feb.	0.073 (6)	0.022 (6)
Average	0.183	0.058

Animal by a Horizontal Haul in the Neighboring Waters of Hirado I.

10	11	12	15	17	18	19	20	23	24
0	0	0	0	0	0	0	0	0	0
(7)	4 (3) 1	9 (43)	2 (20)	2 (17)	13 (11)	7 (5) 7	23 (5) 12	3	92 (1) 6
10 91	9 480 4	123 1305 10	77 640 3	51 675 4	12 634 4	68 1905 6	71 3778 10	8 554 55	33 1113
	5	11	29	6	5	38	23	4	1
3	17	125	144	121	133 1	712	649	5 1	243
2	7	475	93	539	835	596	1213	3	119
8	5	4			8	12	31		

Tab. 8. Cell number per liter (Diatoms, Dinoflagellates and Silicofla-

YEAR	DATE	SURFACE					
		DIATOMS			DINOFLAGE-LLATES	SILICOFLA-GELLATES	TOTAL
		SKELETONEMA	CHAETOCEROS	OTHER			
1959	20/4	51,000	35,250	24,250	250	0	110,750
	22/4	43,750	44,250	23,250	250	0	111,500
	24/4	52,250	90,500	33,500	250	0	176,500
	27/4	63,000	108,000	54,000	0	0	225,000
	30/4	9,250	25,250	10,750	0	0	45,250
	2/5	12,000	4,750	13,750	0	0	30,500
	4/5	6,750	5,000	250	750	0	12,000
	6/5	5,750	15,000	3,750	0	0	24,500
	7/5	42,250	19,250	23,250	0	0	84,750
	11/5	129,250	21,750	67,250	0	0	218,250
	13/5	202,500	33,750	39,000	0	250	275,500
	15/5	1,252,500	188,000	157,250	0	0	1,597,750
	18/5	709,000	186,250	66,250	250	250	962,000
	20/5	1,053,750	602,500	81,000	250	250	1,737,750
	22/5	764,000	348,000	29,250	250	250	1,141,750
	26/5	1,940,400	678,000	56,500	0	250	2,675,150
	31/5	4,264,500	184,500	46,750	0	250	4,496,000
	6/6	1,073,750	121,500	52,000	0	2,000	1,249,250
	11/6	1,324,500	185,250	92,000	0	750	1,603,500
	15/6	1,902,250	815,000	194,500	500	0	2,912,250
	18/6	899,840	430,253	127,750	250	0	1,458,093
	22/6	372,993	322,750	265,000	250	0	960,993
	26/6	642,688	573,250	207,500	1,000	250	1,424,688
	30/6	714,648	608,500	131,000	500	500	1,455,148
	4/7	1,488,678	1,228,750	246,750	0	250	2,964,433
	8/7	289,365	599,603	221,250	0	0	1,120,218
	11/7	819,938	1,390,953	322,750	250	250	2,534,141
	15/7	75,500	5,250	2,750	0	0	83,500
	18/7	174,795	40,500	14,500	250	0	230,045
	24/7	23,750	33,000	165,000	4.250	0	226,000
	31/7	2,228,695	118,388	34,500	5,500	1,000	2,388,083
	20/8	65,250	264,000	29,750	500	500	360,000
	24/8	2,000	135,500	36,750	0	0	174,250
	26/8	8,250	454,713	33,750	0	500	597,213
	4/9	91,750	572,750	110,000	250	0	774,750
	7/9	30,250	47,750	15,000	500	0	93,500
	10/9	166,750	2,250	73,500	500	0	243,000
	14/9	37,750	0	50,500	750	250	89,250
	18/9	67,500	5,500	64,500	0	3,000	140,500
	21/9	1,182,500	31,500	224,000	250	2,500	1,441,000
	25/9	580,250	30,250	99,750	0	1,000	711,250

gellates), surface and bottom, at the SAKIBE Station, SASEBO.

BOTTOM					
DIATOMS			DINOFLAGE-LLATES	SILICOFL-AGELLATS	TOTAL
SKELETONEMA	CHAETOCEROS	OTHER			
3,000	57,000	35,000	1,250	0	96,250
6,500	22,750	29,750	1,000	0	60,000
2,500	4,250	13,000	0	0	21,750
750	0	3,000	250	0	4,000
2,250	500	11,500	250	0	14,500
0	1,500	14,750	0	0	16,250
22,000	1,750	35,250	0	0	59,000
52,500	3,750	6,750	250	0	63,250
330,500	65,500	37,250	0	1,000	434,250
223,250	29,000	18,750	0	0	271,000
336,750	14,250	19,750	1,250	4,750	376,750
216,250	22,250	12,250	250	1,500	252,500
529,000	28,000	54,750	750	250	612,750
990,000	172,000	81,500	0	2,500	1,246,000
700,500	170,750	194,250	0	2,000	1,067,500
243,750	130,250	185,250	250	1,250	560,750
406,750	377,750	130,750	0	2,250	917,500
263,000	598,500	122,750	250	500	985,000
201,500	599,250	123,250	250	250	924,500
201,000	426,750	122,000	0	250	750,000
96,750	113,250	83,250	500	0	293,750
43,250	11,000	20,750	250	250	75,500
18,500	500	18,000	250	0	37,250
4,000	5,000	16,250	750	500	26,500
12,500	10,750	14,750	94,250	77,000	209,250
38,750	140,000	66,750	250	2,250	598,000
25,750	61,250	47,750	250	1,750	136,750
22,750	39,500	59,250	250	750	122,500
5,250	18,250	23,000	0	250	46,750
27,500	19,750	22,500	0	0	69,750
7,000	250	7,000	0	1,000	15,250
45,250	1,500	23,000	0	1,250	71,000
257,250	3,500	141,500	0	2,250	404,500
356,500	11,000	73,000	0	2,000	442,500

Table 8. Cell number per liter (Diatoms, silicoflagellates), surface

YEAR	DATE	SURFACE					
		DIATOMS			DINOFLAGE-LLATES	SILICOFLA-GELLATES	TOTAL
		SKELETONEMA	CHAETOCEROS	OTHER			
	1/10	11,000	6,250	13,500	0	1,500	32,250
	5/10	4,250	250	4,750	0	500	9,750
	9/10	1,250	0	5,750	0	250	7,250
	12/10	750	0	8,000	0	750	9,500
	15/10	7,000	0	15,000	0	250	22,250
	19/10	500	500	5,750	0	0	6,750
	22/10	5,250	750	3,750	500	250	11,250
	29/10	3,750	0	4,500	0	0	8,250
	2/11	5,750	750	12,000	250	0	18,750
	5/11	24,250	3,250	30,250	250	750	58,750
	9/11	17,750	750	5,750	0	2,500	26,750
	12/11	31,250	250	8,500	0	1,000	41,000
	17/11	95,000	1,750	8,000	500	5,500	110,750
	20/11	22,500	1,750	2,250	0	2,500	29,000
	26/11	18,250	9,750	34,750	1,750	1,500	66,000
	1/12	16,250	39,000	16,000	500	250	72,000
	3/12	12,500	65,000	23,250	1,000	0	102,250
	6/12	41,750	75,750	26,250	500	250	144,000
	11/12	31,500	71,000	5,750	750	0	119,000
	14/12	31,500	10,250	11,500	500	0	53,750
	17/12	48,750	16,250	11,000	250	0	76,250
	21/12	65,750	13,750	24,500	250	250	104,500
	24/12	158,000	32,000	70,750	750	250	261,750
	28/12	137,000	25,000	26,250	2,000	1,000	191,250
	31/12	109,750	28,500	39,750	2,500	0	180,500
1960	4/1	120,250	24,000	19,000	500	0	163,750
	7/1	56,500	58,500	58,750	1,500	0	155,250
	11/1	71,000	59,750	54,250	750	0	185,750
	14/1	140,000	144,250	141,500	1,750	250	427,750
	18/1	65,250	26,750	36,750	1,500	0	130,250
	21/1	94,250	27,000	43,000	500	250	165,000

and bottom, at the SAKIBE Station, SASEBO. (continued)

BOTTOM					
DIATOMS			DINOFLAGE-LLATES	SILICOFL-AGELLATES	TOTAL
SKELETONEMA	CHAETOCEROS	OTHER			
3,000	1,750	9,500	0	1,250	15,500
1,000	0	4,750	0	500	6,250
2,000	1,250	4,000	0	500	7,750
2,000	0	10,250	0	250	12,500
500	1,000	10,000	0	250	11,750
4,250	0	6,500	0	500	11,250
0	0	6,500	0	0	6,500
0	500	7,500	0	0	8,000
14,250	1,750	15,500	250	0	31,750
750	3,500	24,000	0	250	28,500
13,500	2,000	3,000	250	1,000	19,500
47,250	6,750	25,250	1,000	1,250	81,500
13,500	1,250	2,750	1,000	2,000	20,500
25,000	3,000	2,750	250	3,500	34,500
20,000	8,750	19,250	250	750	49,000
11,500	75,000	17,750	250	1,000	105,500
9,000	95,000	12,250	250	250	116,750
35,500	50,750	26,000	500	250	113,000
15,000	71,500	11,750	750	250	99,250
23,750	125,000	6,000	250	250	155,250
41,500	24,000	18,500	500	0	84,500
57,750	18,500	40,900	0	250	117,400
113,750	31,750	75,750	500	0	221,750
74,250	25,000	37,000	500	500	137,250
77,500	23,250	70,250	1,750	0	172,750
114,750	32,250	43,000	1,250	0	192,250
101,500	49,750	47,000	1,250	0	199,000
147,750	93,750	94,000	500	0	336,000
136,750	55,250	77,750	1,500	250	271,250
30,000	25,750	33,750	1,000	500	91,000
160,000	70,250	52,750	750	0	283,750

Records of Oceanographic Works
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ON THE CATCH FLUCTUATIONS OF THE JAPANESE ANCHOVY IN THE WATERS OFF WESTERN KYUSHU

By

Koji Takeshita and Hiroaki Aikawa

(Laboratory of Fisheries, Faculty of Agriculture, Kyushu University)

This is a preliminary report on the fluctuation of the commercial population size of the Japanese anchovy in the coastal waters off western Kyushu, based on the statistical catch and effort data during the period of six years from 1953 to 1958.

The waters off western Kyushu belong to the East China Sea Region, one of the Divisions in Japan for describing statistics by the Statistics and Survey Division, Ministry of Agriculture and Forestry. In this region, anchovy fishery centered in Nagasaki Prefecture with the greatest bulk of the landings, followed by Kumamoto and Saga Prefectures, and about 85 percent of anchovy catch in this region is landed in these three prefectures. This report deals with the statistical data of these three prefectures to discuss the fluctuation of the commercial population size of anchovy in the waters off western Kyushu (Fig. 1). Catch and effort data are based on those by the Statistics and Survey Division, Ministry of Agriculture and Forestry. Data of body length composition were referred to the Report B issued by the Seikai Regional Fisheries Research Laboratory, as well as on the data of our collection since 1954 in mainly Nagasaki and Saga Prefectures.

Yearly Variations of the Catch per unit Effort

Anchovies are caught mainly by the surrounding nets and secondly by the beach and boat seine nets in the waters off western Kyushu (Fig. 2). Yearly variations of the commercial population size are examined by the catch per converted trip about four fishing gears of the purse seine nets (circular moored nets) of pair boat operation, the sardine semi-surrounding nets, the beach and the boat seine nets (Table 1, 1~4). The number of converted trip is obtained by correcting the number of crude trip with the catch per trip of the standard size boats which are dominant in the number of trip and the catch amount.

(Sardine semi-surrounding nets) Catch per converted trip is increasing yearly, and the number of converted trip is nearly constant for the year 1956, 1957 and 1958, while the ratio of the anchovy catch to the total remains around 50 percent from 1955 to 1958. It is assumed that the commercial population size of anchovy is increasing.

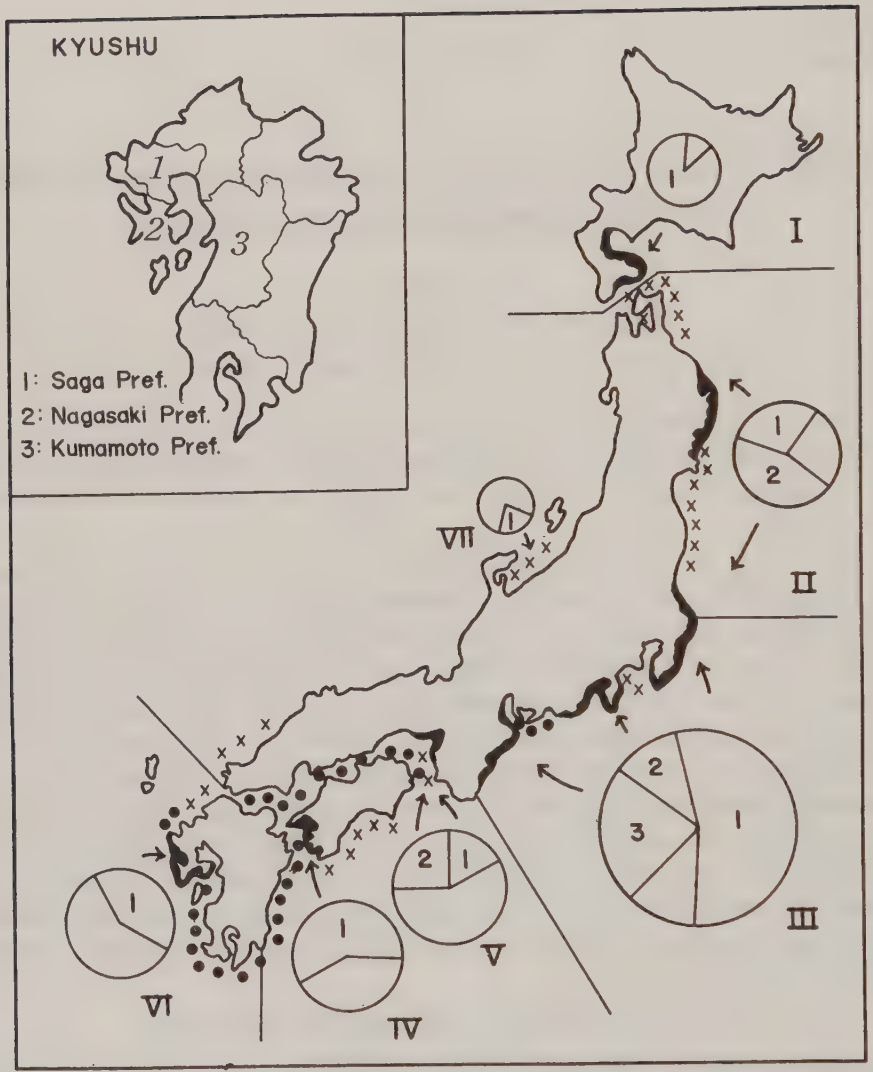

Fig. 1. Japanese anchovy distribution inshore
Data from commercial catch, on an average of seven years, 1952–1958

Note:
I. Hokkaido Region, annual catch: 16.8×10^3 ton 1. Osima
II. Pacific North Region, annual catch: 47.8×10^3 ton
1. Iwate and 2. Ibaragi Pref.
III. Pacific Middle Region, annual catch: 125.7×10^3 ton
1. Chiba, 2. Shizuoka and 3. Mie Pref.
IV. Pacific South Region, annual catch: 41.6×10^3 ton
1. Ehime Pref.
V. Seto Inland Sea Region, annual catch: 65.0×10^3 ton
1. Hyogo Pref.
VI. East China Sea Region, annual catch: 37.4×10^3 ton
1. Nagasaki Pref.
VII. Japan Sea Region, annual catch: 8.6×10^3 ton 1. Toyama Pref.

■ : over 10^4 tons in annual catch by prefecture
●●●● : over 0.5×10^4 to 10^4 tons
×××× : over 10^4 tons in annual catch by prefecture

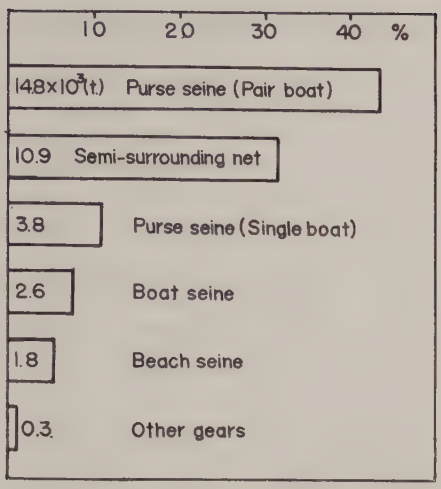

Fig. 2. Catch of anchovy by the type of fishery in the waters off western Kyushu

Table 1. Catch per converted effort

(1) Sardine semi-surrounding nets (Standard: Non-powered boats)

Year	1953	1954	1955	1956	1958	1959
1. B	248	225	218	175	156	137
2. g (10^3)	13.4	18.6	18.1	12.8	12.7	13.8
3. X (10^3)	14.1	19.8	15.5	10.0	10.4	11.7
4. Y (ton)	30,919	27,653	20,955	23,385	21,499	25,096
5. Y/X (kg)	(2,192.8)	(1,396.6)	(1,351.9)	(2,338.5)	(2,067.2)	(2,145.0)
6. Y (ton)	3,808	7,140	10,658	9,495	10,242	13,011
7. Y_A/X (kg)	(270.1)	(360.6)	(687.6)	(949.5)	(984.8)	(1,112.0)
8. Y_A/Y (%)	12.3	25.8	50.9	40.6	47.6	51.8

(2) Purse seine nets of Pair boat operation (Standard: Non-powered boats)

Year	1953	1954	1955	1956	1958	1959
1. B	244	202	199	199	188	167
2. g (10^3)	10.7	19.0	18.4	16.4	14.7	13.6
3. X (10^3)	12.6	23.3	22.2	18.0	14.6	14.2
4. Y (ton)	28,684	68,284	52,455	39,555	36,833	31,110
5. Y/X (kg)	—	(2,930.6)	(2,362.8)	(2,197.5)	(2,522.8)	(2,190.8)
6. Y_A (ton)	—	12,319	17,111	13,785	14,674	16,210
7. Y_A/X (kg)	—	(528.7)	(770.8)	(765.8)	(1,005.1)	(1,141.5)
8. Y_A/Y (%)	—	18.0	32.6	34.9	39.8	52.1

(3) Beach seine nets (Standard: Non-powered boats)

Year	1953	1954	1955	1956	1957	1958
1. B	445	411	447	395	320	295
2. g (10^3)	22.9	18.8	19.2	16.8	13.2	13.3
3. X (10^3)	21.2	16.2	18.4	14.9	11.1	12.0
4. Y (ton)	7,526	6,026	7,770	4,485	3,716	4,598
5. Y/X (kg)	(355.0)	(372.0)	(422.3)	(301.0)	(334.8)	(383.2)
6. Y_A (ton)	1,001	1,759	2,506	1,916	1,890	2,047
7. Y_A/X (kg)	(47.2)	(108.6)	(136.2)	(128.6)	(170.3)	(170.6)
8. Y_A/Y (%)	13.3	29.2	32.3	42.7	50.9	44.5

(4) Boat seine nets (Standard: 0–5t, Powered boats)

Year	1953	1954	1955	1956	1957	1958
1. B	1,485	1,433	1,490	1,483	1,402	1,417
2. g (10^3)	67.5	67.7	75.8	80.9	80.9	97.5
3. X (10^3)	90.5	77.2	92.1	82.9	84.2	124.0
4. Y (ton)	5,801	4,950	5,914	6,311	6,150	8,666
5. Y/X (kg)	(64.1)	(64.1)	(64.2)	(76.1)	(73.0)	(69.9)
6. Y_A (ton)	770	1,579	2,265	2,138	3,034	3,553
7. Y_A/X (kg)	(8.5)	(20.3)	(24.8)	(25.8)	(36.0)	(28.7)
8. Y_A/Y (%)	13.3	31.9	38.3	33.9	49.3	41.0

Note:
1. B; Number of actual boat
2. g; Number of crude trip
3. X; Number of converted trip
4. Y; Total landing
5. Y/X; Total landing per converted trip
6. Y_A; Landing of anchovy
7. Y_A/X; Landing of anchovy per converted trip
8. Y_A/Y; Percentage of landing of anchovy to total landing

(Purse seine nets of pair boat operation) This type nets are operated mostly by non-powered boats of small size in this water region, and anchovies more "shore bound" than most of the other pelagic fishes are important in this fishery. It is more appropriate to estimate the changes of the commercial anchovy population size by the catch per unit effort of this type nets rather than the purse seine nets of single boat type, which is operated generally by the powered boats of large size with more selectivity for the other pelagic fishes as the mackerel and the jack mackerel.

Both the catch per converted trip and the catch of the anchovy are increasing with exceptional ascending in 1955, in spite of successive decreasing in the number of converted trip.

(Beach and Boat seine nets) Catch per converted trip is increasing in

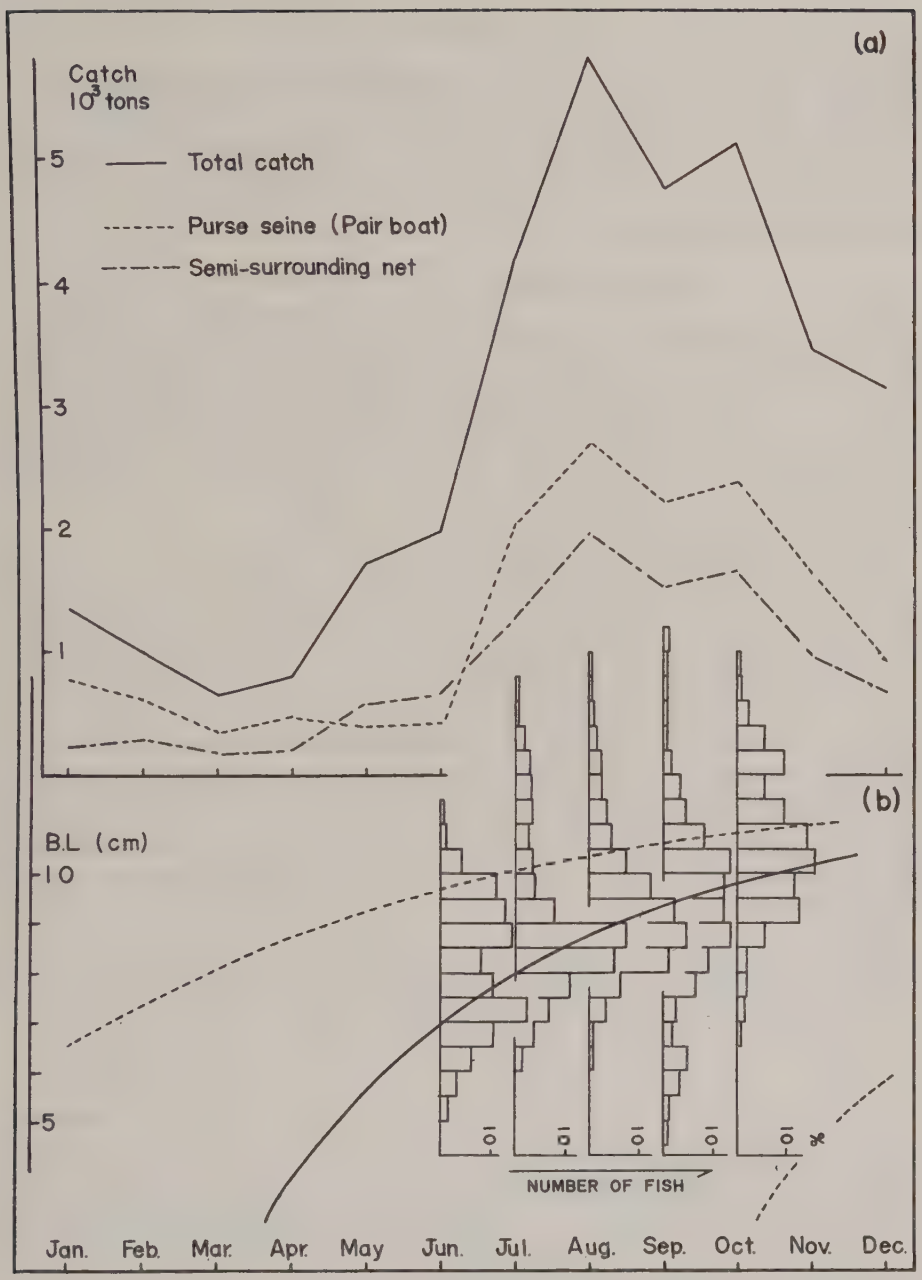

Fig. 3a. Monthly changes of the anchovy catch
b. Body length composition in the main fishing season, and the growth curve estimated from the scale method

Note: ——— spring brood group
..... autumn brood group

the both gears with exception in the case of boat seine nets in 1958. No signs stand for the decreasing of stock size.

Most of the small size anchovies are caught mainly by the beach and the boat seine nets, while the middle and large size groups are mostly caught by the surrounding nets. The commercial population size of anchovy is not decreasing in this water, with the upward tendency of the catch and the catch per converted trip by all these fishing gears.

Monthly Changes of the Catch Amount

Monthly fluctuation of the anchovy catch varies similarly year by year with the great bulk of the catch in the latter half of a year, from July to December, and the annual catch amount is mostly supported by the catch in this period. On the catch data, anchovy fishing is conducted almost by using the surrounding nets especially the purse seine nets of pair boat operation and the sardine semi-surrounding nets, the annual and the monthly catches also depend mainly on those by these two gears (Fig. 3 a).

During the main fishing season from July to October, body-length compositions in samples from the catch by the surrounding nets are unimodal with the mode between 7.0 cm and 10.0 cm of the middle size group, though with wide variation to the large size group over 10.0 cm in body length. With the consideration of the growth of anchovy in this water by the scale method, these modal groups of the middle size comprise mostly the spring brood group (Fig. 3 b), though about the large size anchovy over 10.0 cm in body length it is difficult to discriminate two seasonal groups of spring and autumn brood only by the length of fish, for the growth rate of anchovy decreases rapidly after around 10.0 cm in body length and the both brood groups are close in body-size.

The first mark-size, r (mm), and the intermediate length, l (mm), based on the scale method, are obtained as below; here, these marks are formed mostly during the period from December to February.

$r_1(S)$	3.21 – 3.98	$r_1(s)$	1.25 – 2.41
$l_1(S)$	102.0 – 121.3	$l_1(s)$	57.0 – 85.8

(S) and (s) denote the spring and the autumn brood groups respectively.

Two seasonal brood groups of the anchovy are analyzed by the biological characters as the number of vertebral bones and the first mark-sizes on scales besides by tracing the modes of monthly body length-compositions, but these two groups can not be discriminated in catch data since these biological informations are not sufficient quantitatively.

However, the spring brood group is far more important than the autumn one in the commercial anchovy fishery for the both small and middle size groups from the size-composition data in the main fishing season. In other words it is assumed that the variation of anchovy catch is attributable to those of the middle size group of spring brood.

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STUDIES ON DITREMA TEMMINCKI I

About the Seasonal Cycle of Mature Testis and the Spermatogenesis

By

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Introduction

Ditrema temmincki is common fish in all the year round in everywhere of the coast of Japan, and is one of the important fishes for the coastal fishermen in this country. The fishes in family Embiotocidae in Japan are *Ditrema temmincki* (Umi-tanago) and *Neoditrema ransonneti* (Oki-tanago), and they are the only marine viviparous teleost, namely they maintain the many larval fishes in their ovary during the long space of time and moreover these larval fishes grow up to about 50 mm in this period. By these reasons this fish is known to all in Japan.

The studies on the behaviour of this fish had been reported by ISHII[1] and UCHIDA[2]. In other countries there are many studies on the sexual behaviour about the viviparous or ovoviviparous teleost in the fresh water, and TURNER[3] had reported in detail about the histological and cytological changes in the ovary of *Cymatogaster aggregatus* which is the fish in family Embiotocidae in American coast. The author have studied about the age, the growth, the maturation of testis and the ovarian cycle of *Ditrema temmincki* which is one species in the Japanese Embiotocidae; in this paper the author reports on the seasonal cycle of mature testis.

Material and Methods

At Sasebo bay which exists in the west side of Kyusyu, the author collected monthly *Ditrema temmincki* in all the year round by the trammel gill net. The fishing ground is shown in Fig. 1 and the period of the collection was through May 1958 to September 1959, and Table 1 shows the monthly catch. In this table the specimens in May and August is very few and that in September is numerous; this is merely because of the frequency of the operation and not of migration of this fish. This fish can be caught in all the year round at Sasebo bay. These facts show that this typical coastal fish does not move largely and lives in the Sasebo bay through the year, and that this monthly specimens are the catches from the same race. The sex-ratio of this fish is not different from male and female on the whole in every month.

Fig. 1. The fishing area

Table 1. Number of specimen by month

Month	Number of specimen	Month	Number of specimen
Jan.	21	Jul.	13
Feb.	19	Aug.	3
Mar.	6	Sept.	63
Apr.	11	Oct.	14
May	2	Nov.	12
Jun.	14	Dec.	10
		Total	188

After the measurement of the body-length, the otolith are collected in order to know the age and growth, and the gonad are collected in both sexes in order to study the sexual behaviour of this fish. The next, the gonad weight was measured and then the testis was fixed by ALLEN-BOUIN'S solution and the ovary by BOUIN'S solution. These works are done nimbly. In this study the author made clear the seasonal cycle of mature testis and the spermatogenesis of this fish in order to know the resting period of the testis, the preparative period for the spermatogenesis, the period of the spermatogenesis and the discharging period of the spermium. The decrease and increase of the monthly testis weight were investigated and the histological sections of the monthly testicle were observed. Aftetr the fixation the testis was sliced into the thin sections by the paraffinimbedding method and these sections were stained in compound stain method by HANZEN'S haematoxylin and eosin and then were observed. The measurement of the testis weight and the making of the histological sections were made about all specimens.

Seasonal Change of the Testis Weight

The testis weight has been indicated by the value of G. I., namely

$$G.I. = G/L^3 \times 10^a$$

G = the testis weight (m. gr.)

L = the fork length (mm.)

G. I. has been called the gonad index and has been used in the ovary weight of female too, and the many Japanese investigators have used this value in order to know the seasonal change of the testis weight about horsemackerel[5], mackerel[6], saury[10] and scorpaenous fishes[4),7),8]. The value of G. I. about each individual specimen was calculated and these values were taken the arithmetic average by month. This monthly average value is Fig. 2. In this figure, it

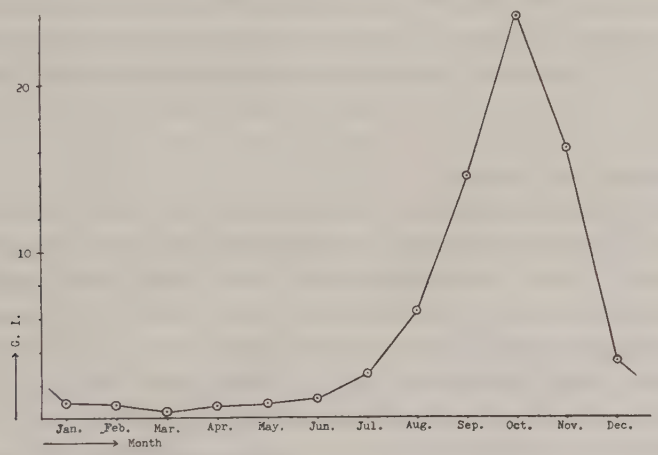

Fig. 2. Monthly weight (G.I.) of testis

is clear that the average value is lower than 1.0 between January and May, and in this period it is guessed that the testis has rested perfectly, but in female the ovary grows up gradually and the larval fishes are brought up in ovary and are born at last in this period. In the next place, the value of June is little over 1.0; this shows that the testis is preparing for the activity in this month, and this fact is proved by the result of the microscopical observation in the next chapter. In June, G. I. increases still more until 2.6 and it is guessed that the activity of the testis has begun. The value in August shows 6.3 and in September it rises suddenly 14.5, and in October G. I. reaches to 24.1 and this is the highest value in the whole year and it is indicated that the activity of the testis in this month is the most vigorous. But in November, this value begins to decrease to 16.2, and in next December it falls to 3.4 suddenly. From these facts, it is clear that the period between September and November has some connection with the maturation of the testis and with male sexual act of this fish in Sasebo bay, but the detailed fact is not plain besides the microscopical observation of

the histological section of the testis. The times when the gonad ripens are disagreed by the two sexes of this fish as well as of the marine ovoviviparous teleost and its difference between male and fmale is six months, however the increase of the ovary weight of this fish is due meinly to the growth of the larval fish in their ovary and not the development of the oocytes in ovary as the oviparous and ovoviviparous teleost. In this paper, the author has treated the specimens only, which reaches in the biological minimum, and did not consider about the age of the specimen.

Histological Observation

The author has made the histological section of all testis of the specimens which were collected all the year round and observed by the microscope to ascertain the maturation and the seasonal cycle of the testis which has been shown in the measurement of the monthly testis weight, and also to know the differences in the inner or outer testis form and the process on the spermatogenesis in the oviparous[12),13),14)], ovoviviparous teleost[8),11)] and fresh water viviparous teleost[16),17),18),19),20),21)].

1. Outer form of the testis

The testis of this fish is very similar in the outer form to that of *Sebastiscus spp.* which are the marine ovoviviparous teleost, which is ordinarily the yellowish slender ellipse and when the little larval fishes have been seen in the ovary of female the testis form becomes very slender but from the latter part of summer its form grows fat in yellowish white and comes near to the egg-form. And in all oviparous fishes the testis turns into a very thin piece like thin paper, and when it has shrinked in the resting period, the testis becomes smaller and slender but does not change its form as it is seen at the resting period. And the testis is not different in right and left parts ordinarily and they are independent of one another and there is no junction between them, and the mesonephric ducts, the length of which is similar to the testis, are connected with the copulatory organ and the posterior end of the each testicle, and then in this testis there are no sperm-storerooms like in *Sebastes spp.*,[8)] which are the marine ovoviviparous teleost.

2. Monthly observation of the histological section of the testis

There is few histological observation about the testis of teleost, but the testis of the fresh water viviparous teleost has been observed comparatively in other countries, namely ESSENBERK (1923)[16)], GEISER (1924)[17)], VAUPEL (1929)[18)], GOODRICH (1934)[19)] and MEDLEN (1950)[20)] had described about the process of the spermatogenesis and the maturation of the testis of *Xiphophorus helleri* (Sword-tail), *Gambusia holbrooki* (Top-minnow), *Lebistes reticulatus* (Guppy), Guppy and Top-minnow respectively. In Japan, ISHII (1957)[1)] and MIZUE (1959)[8),11),15)] had reported and stated about the observation of the testis of *Ditrema temmincki* and scorpaenous fishes which are the marine viviparous or ovoviviparous teleost.

The one cycle of the maturation in the testis of this fish is one year as it has been made clear in the former chapter, excepting the points that the process of the spermatogenesis of this fish is similar to that of *Xiphophorus helleri* and *Gambusia affinis*, and it very resembles to *Gambusia holbrooki*, *G. affinis* and *Lebistes reticulatus* particularly which the many spermatozoon in this fish form the sperm-ball at the seminiferous tubule in the last stage of the spermatogenesis. And the testis of this fish consists of the seminiferous tubules and is the tubular type testis as ISHII[1] and MIZUE[8),15)] has pointed out. In the next place the histological sections of the testis are explained by the microscopical figures (Plates 1–4) in regular order from January.

The sections of 21 specimens which had been collected in January have shown that the action of the testis has come to end entirely as indicated in Plate 1, Nos. 1 and 2, namely, the seminiferous tubules which had discharged the sperm-balls begin to shrink in general in this month but there is still a few refuse of the sperm-ball in the duct at the central portion of the testes. And in the sections of this month there are many interstitial connective tissues and interstitial cells between the seminiferous tubules, and a few spermatogonia come out in every seminiferous tubules without exception and some of these spermatogonia have segmented; it is no doubt that this segmentation is abnormal. In scorpaenous fishes[8),11)] the spermatogonia have not appeared for about six months after the discharging period of the spermium.

In the sections of 19 specimens which had been collected in February the seminiferous tubules have shrinked fully as it has been indicated in Plate 1, Nos. 3 and 4 and the volume of the interstitial connective tissue and interstitial cell between the seminiferous tubules is almost equal to that in former month but the spermatogonia in the seminiferous tubule which has appeared between the basement menbrane and the seminiferous epithelium is more clear and numerous than in former month. This condition of the testis in February continues untill May.

The sections of 6 specimens in March, 11 specimens in April and 2 specimens in May have been shown in Plate 1, Nos. 5, 6, 7 and 8 respectively, and it is known that these are the same condition with that of February.

Plate 2, Nos. 9 and 10 are the histological figures of the testicle in June (14 specimens). By these figures it is shown that the spermatogonias appeare without reserve for the lumen more abundantly than the former month and they get bigger to some extent and are more clear. And the histological figures which the spermatogonia begins to segment have been seen in everywhere at the seminiferous tubules but it has not been observed yet that a spermatogonia develops to a cyst for the lumen. There are many interstitial connective tissue and cell in this month as before.

13 specimens had been collected in July, and these testicle had been sliced about every one and observed. Plate 2, Nos. 11–14 are these histological

figures. The spermatogonias at the seminiferous tubules develop in size and number to a certain extent and form a cyst. And in the cyst it has been seen that a nucleus of the spermatogonia performs the cyncytium and increases to many sperm cells of the advanced stage. And in some specimen there are many seminiferous tubules in the testis which had many advanced cysts. It is no doubt that a cyst is formed from a spermatogonia in the seminiferous tubule and this is the same fact at *Sebastiscus marmoratus*[11] and *Sebastes inermis*[8] etc. In the seminiferous tubule a portion of the lumen makes an empty space still in this month and the interstitial cell and connective tissue exist numerously.

The specimens were few in August, since all the spermatogonias progressed to the considerably advanced cysts, especially there are many cysts of the various stages in the seminiferous tubule at the central portion of the testis, and the part of the lumen has hardly existed as the many cysts have expand for the lumen, but every sperm cell in this month has not yet formed the sperm-ball in the seminiferous tubule and there are many interstitial cells among the seminiferous tubules. Plate 2, Nos. 15 and 16 show the histological figures of the testis of this month.

The specimens of September were numerous compared with other months and the author has made the histological sections of the testicle about the 63 specimens and observed them. Among these specimens the testis in the very advanced stage had the seminiferous tubules which had formed many sperm-balls and some of them were the primary condition of the spermatogenesis. But on the whole it may be safe to say that the condition in the testis of all specimens begins the spermatogenesis violently all together. The sperm-cell in the seminiferous tubule at the central portion of the testis is more advanced stage than the surrounding portion, and the interstitial connective tissue is pressed and narrowed by the expanded seminiferous tubules and there are the stained interstitial cells in red by eosin between the seminiferous tubules in a line. And then the part of the lumen does not make an empty space and has been pluged by the expanded cysts in the seminiferous tubule. And the seminiferous epithelium could not be noticed in the seminiferous tubules in this month. Plate 3, Nos. 17–20 show the histological figures about the testis of September.

14 specimens had been collected in October and their histological figures have been shown in Plate 3, No. 21 and Plate 4, No. 27. As it has been made clear in these figures, that this month is the height for the spermatogenesis, and the testis is most filled up, and the cysts and sperm-balls in their various stages are observed, and the seminiferous tubule expands to the heighest degree. And then the mesonephric ducts of all specimens after the middle of this month are filled by the many sperm-balls which are sent from the seminiferous tubules. It is supposed that Ditrema temmincki in Sasebo bay copulates at the middle of October from the histological figures of the testis. Indeed, in the histologi-

cal sections of the ovaries of this fish have been collected in Sasebo bay between the middle of October and the first half of November.

12 specimens have been collected in November and the histological figures of these testicle are shown in Plate 4, Nos. 28–30. The figure of the seminiferous tubule of the testis in this month shows a characteristic form, namely the seminiferous tubules are expanded extremely, but the portion of the lumen in the tubule is empty. The reason for it is that the sperm cell and the cyst have been lacked to fill the seminiferous tubule. This is indicated that the activity of the testis comes near to the end, and it is seen in the seminiferous tubule that the seminiferous epithelium stands thinly on the basement membrane. And in the seminiferous tubule and the mesonephric duct of the last decade of this month there is a few sperm-balls in company with the refuse. It is guessed that the copulatory term comes to end at the end of November.

The seminiferous tubule of the testis which has been collected in December does not shrink yet and there is entirely no sperm-ball at the seminiferous tubule and mesonophric duct and is much refuse on the occasion of the spermatogenesis in the mesonephric duct. And it is observed faintly that the seminiferous epithelium exists newly on the basement membrane for the lumen in the seminiferous tubule. Plate 4, Nos. 31 and 32 show the histological figures of the testis in November.

Discussion

1. About the seasonal cycle of the stage of maturity of testis

At the last decade of November there is no sperm-ball in the mesonephric duct and seminiferous tubules as seen by the result of the monthly measurement of the testis and observations of the monthly histological sections, and it could be said that the resting period of the testis has begun from this time and this resting condition of the testis continues untill the last decade of May. Therefore this term is considered as the resting period of the testis in *Ditrema temmincki* at Sasebo bay. In June the spermatogonia which has appeared on the basement membrane for the lumen in the seminiferous tubule of the testis grows and becomes clear, and some of them begin the segmentation. The sperm cell in July advances to some extent but generally speaking, not too much difference is recognized, compared with June. So this two months are the preparatory period for the spermatogenesis. In August many spermatogonias begin segmentation and form the cysts in the seminiferous tubule, and in September the spermatogenesis are performed in all together and it is the height of the spermatogenesis on October, accordingly these three months are considered as the period of the spermatogesnesis. From the existence of the sperm-ball in the testis or ovary the copulatory term at Sasebo bay is between the end of October and the first half of November. The measuremental and histological condition of the testis can be divided into the above four

categories and repeats these categories in every year periodically, namely

1. The preparative period for the spermatogenesis—June–July
2. The period of the spermatogenesis—August–October
3. The discharging period of the spermium (The copulatory period)—The last decade of October the first decade of November
4. The resting period—The last decade of November–May.

The period of the spermatogenesis is shrot comparatively and it is once a year as it is seen by the marine ovoviviparous teleost, but there are many spermatogonias in the resting condition on the basement membrane in the seminiferous tubule at the resting period in this fish.

2. About the relation between the weight of the testis and the microscopical observation of the sections

In Fig. 2 the value of G. I. between January and May is not over 1.0 and in the microscopical observation the testis rests entirely during these months and the relationship of both results coincides rather well. In June G. I. is slightly over 1.0 and the spermatogonia in the seminiferous tubule begins to grow and the testis begins to get out from the resting period. In next July the value of G. I. increses to 2.6 and the spermatogonia advances in some extent and it is regarded as the preparatory period for the spermatogenesis as well as the former month. And in the next three months the value of G. I. rises suddenly and in October it shows the heighest value. During these months the spermatogenesis acts vigorously in the seminiferous tubule. But in November G. I. begins to decrease to 16.2. This is due to that the empty space has been produced in the cyst and seminiferous tubule when the sperm cells form the sperm-ball at the last stage of the spermatogenesis and the sperm-balls are discharged for copulation. In December the value decreases suddenly to 3.4 because of the activity of the testis and also copulation has come to end and the testis has shrunk quickly.

As mentioned above, the monthly change of the value of G. I. coincides closely with the result of the histological observation of the monthly testis and then the period when the weight of the testis is highest in this fish is the period at the height of the spermatogenesis and is not the copulatory period which is also seen in the marine ovoviviparous fishes.

3. About the origin of the spermatogonia

In this fish the spermatogonia appeares between the basement membrane and the seminiferous epithelium in the seminiferous tubule when the spermium had been discharged at the end of November. It is not considered that the spermatogonia penetrates from the outside of the seminiferous tubule and the exterior of the testis. The place where the spermatogonia appears in the seminiferous tubule is exactly the same in scorpaenous fishes. There are many arguments since before about the origin of the spermatogonia, but in the recent time the opinion is about to be established that the spermatogonia appears from the inside of the seminiferous tubule in generally,

as GOODRICH[19], WOLF[21], VAUPEL[18], TAKETA[22], NISHIKAWA[12),13], TOGARI[23] and MIZUE[8),11] had pointed out that the spermatogonia derives in the testis moreover in the seminiferous tubule. It is appropriate in this fish that the sperm cell is supplied from the epithelium cell in the seminiferous tubule and the sperm cell exists in the epithelium and is not formed by the changed epithelium cell as TOGARI[23] had related about the spermatogenesis of the mammalia.

4. About the formation of the sperm-ball

The spermatogenesis in *Ditrema temmincki* greatly resembles to the scorpaenous fishes which had been reported by MIZUE[8),11] and the spermatogonia performs the syncytium and forms the coenocytes. That is, the cell-wall of a spermatogonia expands gradually with the segmentation of its nucleus and forms a cyst and the many sperm cells in the state of the advanced stage are included in a cyst. A nucleus of a spermatogonia segments and incresaes in number and advances to spermatocyte, spermatid, spermatozoon and spermium. And all the sperm cells in a cyst are certainly the condition of the same stage. The spermatogonia which is the first stage sperm cell is not stained enough by eosin or especially haematoxylin, but in the later stages of the spermatogenesis the sperm cell gradually decreases in size and becomes internally compact and more stainable by haematoxilin. The one characteristic point in spermatogenesis of *Ditrema temmincki* is the formation of the sperm ball as GEISER[17] and VAUPEL[18] had reported about *Gambusia holbrooki* and *Lebistes reticulatus* which are the fresh water viviparous fishes, that in the last stage of the spermatogenesis the secretion is produced in the cyst as in *Sebastes inermis*[8] and the many spermiums which are the sperm cells of the last stage of the spermatogenesis gather around the secretion and are supported and supplied with the nutrition by the secretion, forming a sperm ball in the centre of the secretion. And the empty space is produced in the cyst as all the sperm cells decrease in size and gather in a sperm ball. It is certain that a sperm ball is formed by a spermatogonia. After that the sperm ball goes out in the seminiferous tubule when the cyst broke and is pushed out to the mesonephric duct.

5. About the weight of the testis

In the marine oviparous teleost like horse-mackerel[5] and mackerel[6] the weight of the testis is very small in the resting period of the testis but when the activity of the testis has prospered its weight and volume become large considerably and it is heavier than the weight of the ovary at the heighest time of the reproduction. But in *Ditrema temmincki* the heaviest testis in the whole year is 2.4 gr. and the testis which rises above 1.0 gr. is very few at the heaviest time of the testis in the reproductive period. The same result is seen in the marine ovoviviparous teleost[8),11]. This fish is viviparous and the transfer of the sperm is done by the copulation and the fertilization is performed in the ovary of female so the loss of the sperm in the fertilization is very few and moreover the number of the oocyte is very few generally especially

in this fish in comparison with the oviparous fish. By these reasons the fertilization in this fish is sufficient by a small quantity and that notably, the testis is not enlarged like the oviparous teleost.

Summary

1) The testis of *Ditrema temmincki* is collected monthly and the seasonal cycle of the testis is guessed by the observation of their monthly histological sections and the seasonal change of the testis weight.

2) The weight of the testis (the value of G.I.) in this fish begins to increase from June and July, and in September it rises suddenly and in October it shows the heighest value in the whole year, and it decreases suddenly in November and December. It is very low between January and May.

3) The heighest time in the weight of the testis coincides with the period at the height of the spermatogenesis, and the discharging period of the spermium is the time which decreases a little at the next month.

4) Like the marine ovoviviparous teleost the testis of this fish does not grow so much. Therefore, the loss of the sperm is very few since the fertilization of this fish is performed in the ovary of female and the number of the oocyte is fewer than the oviparous fish.

5) The stage of the maturity of the testis could be divided into four from the histological observation, that is

1. The preparative period for the spermatogenesis—June–July
2. The period of the spermatogenesis—August–October
3. The discharging period of the spermium (The copulatory period)—The last decade of October—The first decade of November
4. The resting period—The last decade of November–May

6) The testis of this fish consists of the many seminiferous tubules and the spermatogonia appears from between the basement membrane and the seminiferous epithelium in the seminiferous tubule.

7) The spermatogonia appears in January a little after the discharge of spermium and it stays in that condition for about half a year.

8) The spermatogonia begins to develop in June and the spermatogenesis performs violently in September all together and the heighest period of it is October.

9) The segmentation of that sperm cell is acted by the syncytium, that is, the cell-wall of the spermatogonia expands gradually and forms a cyst, and the nucleus segments to many advanced sperm cells. A cyst is formed by a spermatogonia.

10) In later stages, in the spermatogenesis the sperm cells gradually decrease in size and become internally compact and more stainable by haematoxylin.

11) In the last stage of the spermatogenesis the secretion is produced in the cyst and many spermium gather around the secretion and are suported

and supplied with the nutrition by this secretion, and a sperm ball is formed in a cyst from a spermatogonia, at that time the cyst breaks and the sperm ball goes out in the lumen of the seminiferous tubule and is pushed out to the mesonephric duct.

12) It is guessed from the observations of the seminiferous tubules that the delivery of the spermium by both sexes is performed during the end of October to the beginning of November at Sasebo bay.

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Plate

Plate 1

No. 1: 15×4, 13 Jan. 1959, F. L.–165 mm., T. W.–0.02 gr., the seminiferous tubules are buried by the many connective tissue and begin to shrink. (F. L.=Fork length, T. W.=Testis weight).

No. 2: 15×4, 13 Jan. 1959, F. L.–152 mm., T. W.–0.03 gr., same condition to No. 1

No. 3: 15×4, 4 Feb. 1959, F. L.–175 mm., T. W.–0.03 gr., the seminiferous tubules have shrunk.

No. 4: 15×10, enlarged photograph of No. 3, there are many spermatogonia in the seminiferous tubule and the connective tissue between the seminiferous tubules.

No. 5: 15×10, 23 Mar. 1959, F. L.–150 mm., T. W.–0.01 gr., same condition to the specimen of February

No. 6: 15×10, 28 Apr. 1959, F. L.–143 mm., T. W.–0.02 gr., same condition to February and March

No. 7: 15×4, 20 May 1959, F. L.–188 mm., T. W.–0.04 gr., same condition to the former month

No. 8: 15×10, enlarged photograph of No. 7, same condition to Nos. 4, 5 and 6

Plate 2

No. 9: 15×10, 21 Jun. 1958, F. L.–160 mm., T. W.–0.06 gr., the seminiferous tubule grows than in the former month to some extent, there are many interstitial cells and connective tissue.

No. 10: 15×40, enlarged photograph of No. 10, the spermatogonias are seen clearly and it is considered that they are the state immediately before the segmentation.

No. 11: 15×10, 21 Jul. 1958, F. L.–154 mm., T. W.–0.10 gr., the seminiferous tubule more grows than June and the spermatogonias begin to segment.

No. 12: 15×40, enlarged photograph of No. 11, it is seen clearly that the spermatogonia begins to segment.

No. 13: 15×4, 22 Jul. 1958, F. L.–156 mm., T. W.–0.15 gr., histological figure in low power, same condition to No. 11.

No. 14: 15×40, enlarged photograph of No. 13, same condition to No. 12, it is seen clearly that the spermatogonia begins to segment in the syncytium, there is a space in the portion of the lumen.

No. 15: 15×10, 21 Aug. 1958, F. L.–145 mm., T. W.–0.3 gr., the seminiferous tubules expand for the spermatogenesis begin all together so there is no space in the portion of the lumen but there are many interstitial cells in this month.

No. 16: 15×40, enlarged photograph of No. 15 it is shown clearly that the spermatogenesis are performed all together in the seminiferous tubules.

Plate 3

No. 17: ×50, 16 Sept. 1958, F. L.–154 mm., T. W.–0.4 gr., the seminiferous tubules are seen clearly, it is the height of the spermatogenesis and all kind of the cyst in the different stages are seen in the seminiferous tubules, there is few interstitial cells.

No. 18: 15×40, 20 Sept. 1958, F. L.–152 mm., T. W.–0.6 gr., the sperm-cells in a cyst show the same stage of development.

No. 19: 15×10, 21 Sept. 1958, F. L.–152 mm., T. W.–0.5 gr., same condition to No. 17, it is seen that a sperm-ball is formed by a cyst.

No. 20: 15×40, enlarged photograph of No. 19

No. 21: ×50, 20 Oct. 1958, F. L.–156 mm., T. W.–0.9 gr., there are many sperm-balls in the seminiferous tubules and the mesonephric duct.

No. 22: 15×10, 20 Oct. 1958, F. L.–156 mm., T. W.–0.9 gr., same specimens to No. 21, there are many sperm-balls at the portion of the lumen and the spermatogenesis performs vigorously in the seminiferous tubules.

No. 23: 15×10, 22 Oct. 1958, F. L.–163 mm., T. W.–0.8 gr., the sperm-balls push out to the portion of the lumen as they have been formed.

No. 24: 15×40, 22 Oct. 1958, F. L.–163 mm., T. W.–0.8 gr., the sperm-cells in the cysts at the different stage

Plate 4

No. 25: 15×10, 23 Oct. 1958, F. L.–188 mm., T. W.–2.2 gr., this testis is the greatest in the weight or volume but that histological figure is the same as No. 23.

No. 26: 15×40, 23 Oct. 1958, F. L.–149 mm., T. W.–0.8 gr., the sperm-cells in the cyst at the different stages were seen clearly.

No. 27: 15×40, 23 Oct. 1958, F. L.–170 mm., T. W.–1.2 gr., same condition as No. 26

No. 28: ×50, 10 Nov. 1958, F. L.–163 mm., T. W.–0.6 gr., each seminiferous tubules are large and the portions of the lumens become empty, in this specimen the spermatogenesis is on the decline.

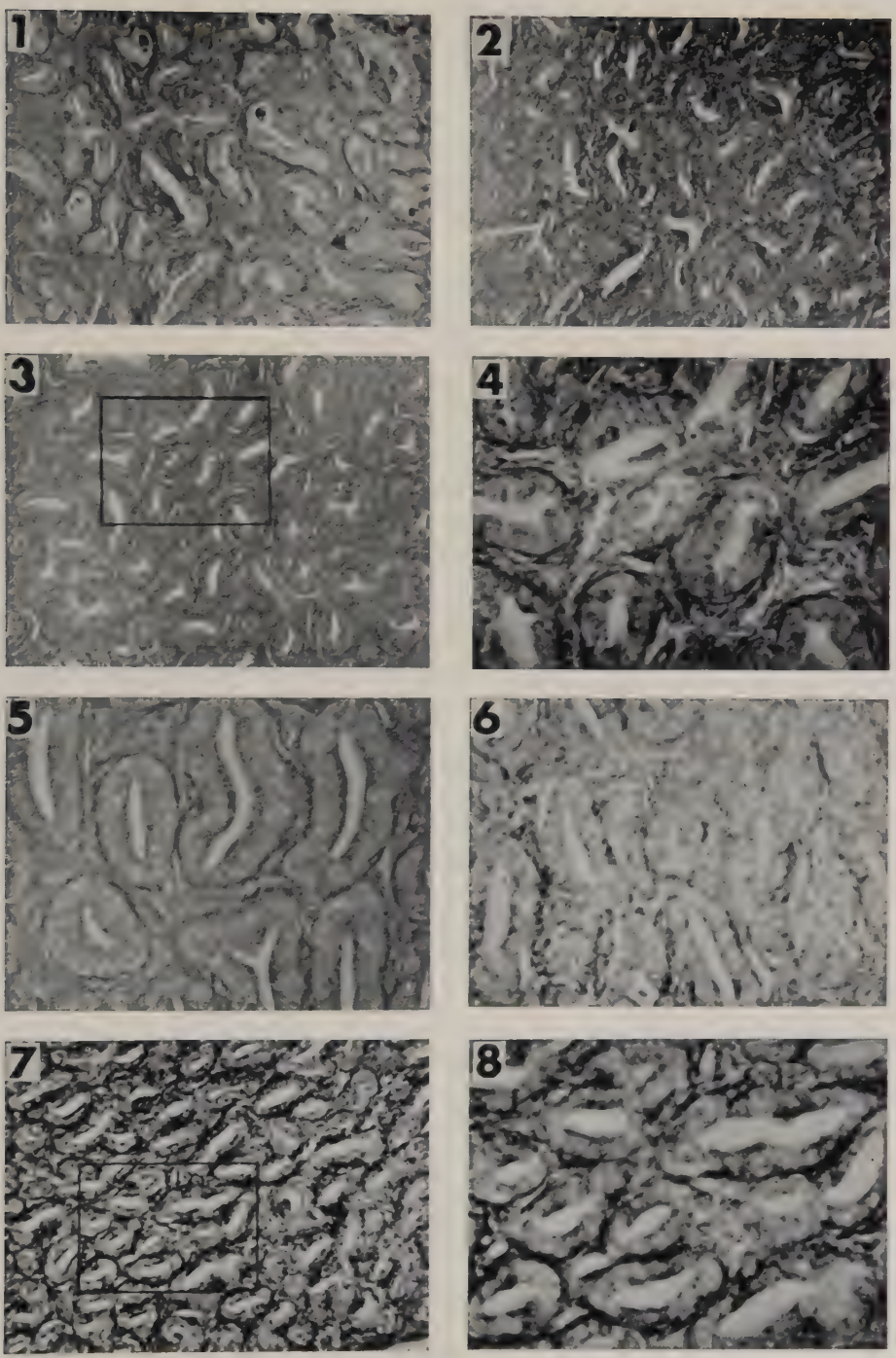
No. 29: 15×4, 14 Nov. 1958, F. L.–152 mm., T. W.–0.5 gr., same condition to No. 28

No. 30: 15×4, 15 Nov. 1958, F. L.–164 mm., T. W.–0.3 gr., there are many sperm-balls in the mesonephric duct but the spermatogenesis comes to end in the surrounding portion of the testis already.

No. 31: 15×4, 25 Dec. 1958, F. L.–164 mm., T. W.–0.2 gr., this histological figure shows that the seminiferous tubules have passed after the discharge of the spermium for a while and shrink to some extent and the interstitial connective tissue increases again suddenly.

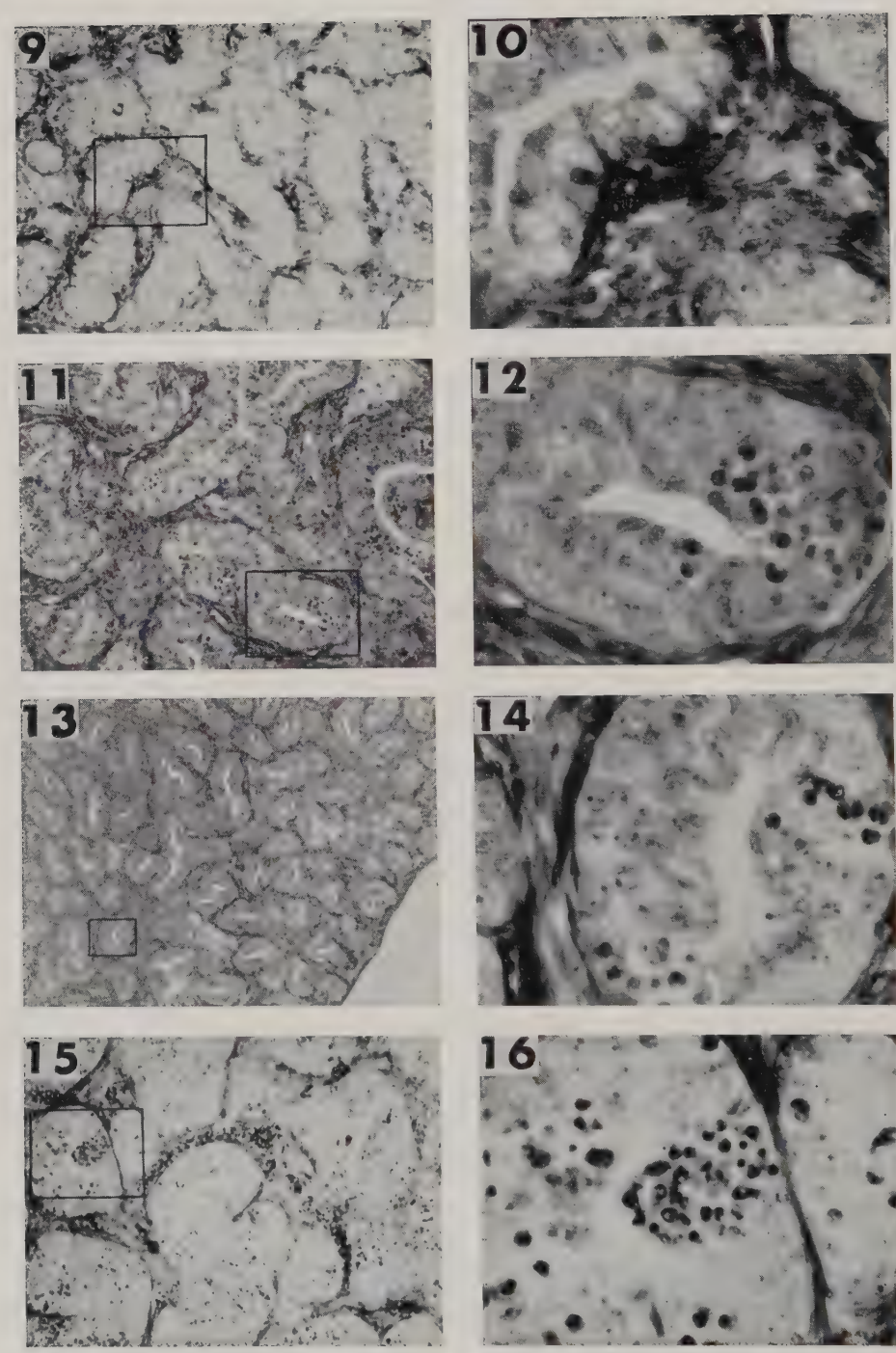
No. 32: 15×4, 15 Dec. 1958, F. L.–162 mm., T. W.–0.1 gr., the seminiferous tubules show the slacken condition after the spermatogenesis and the discharge of the spermium.

PLATE 1



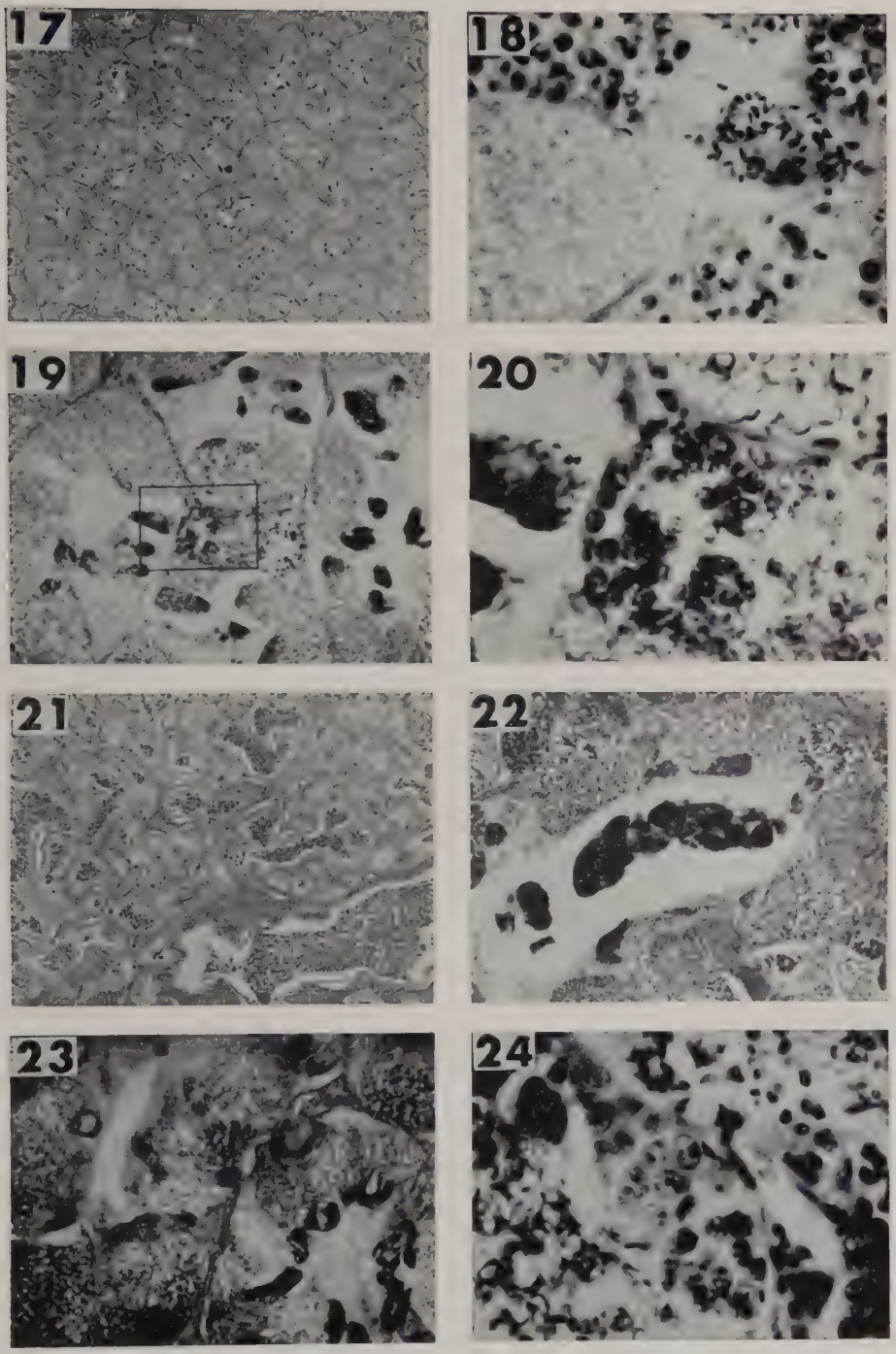
K. MIZUE: About the Seasonal Cycle in the Testis of *Ditrema temmincki*

PLATE 2



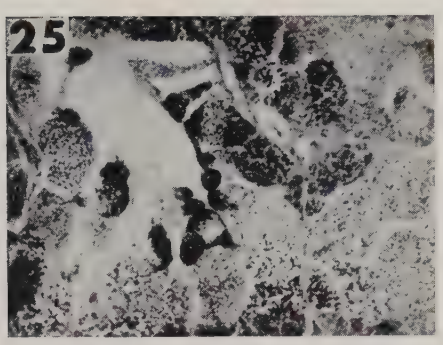
K. MIZUE: About the Seasonal Cycle in the Testis of *Ditrema temmincki*

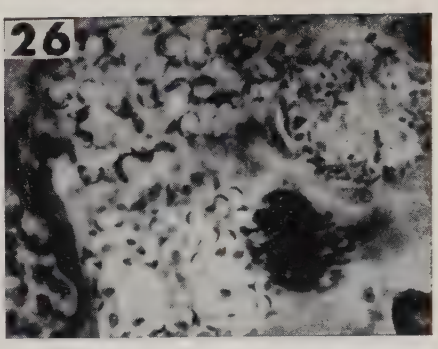
PLATE 3

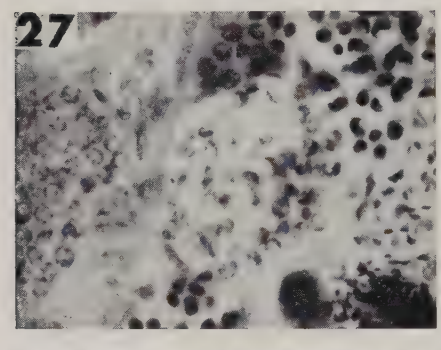


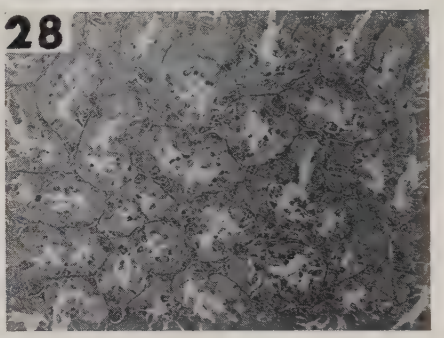
K. MIZUE: About the Seasonal Cycle in the Testis of *Ditrema temmincki*

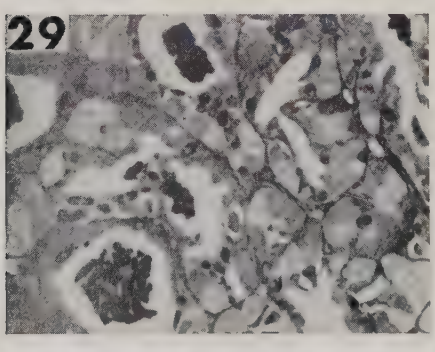
PLATE 4

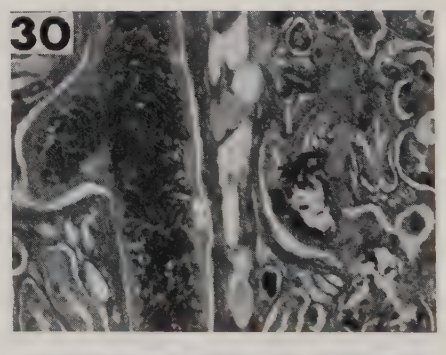


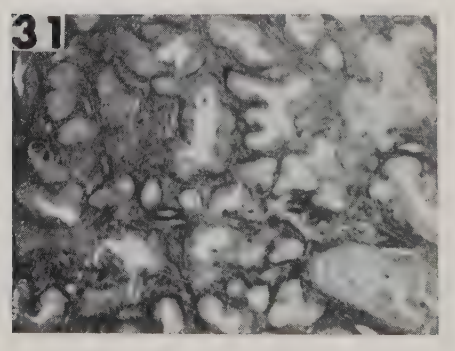


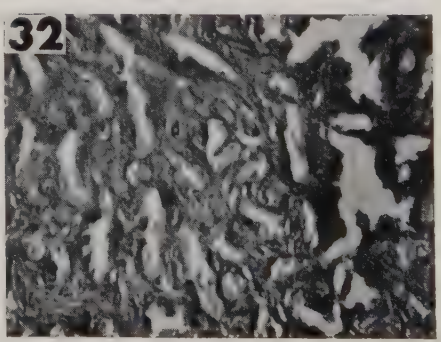












K. MIZUE: About the Seasonal Cycle in the Testis of *Ditrema temmincki*

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March 1961

ON THE MATURATION AND SPAWNING BEHAVIOR OF THE MACKEREL, *SCOMBER TAPEINOCEPHALUS* (BLEEKER), ON THE EAST CHINA SEA REGION

By

Sumio Enami

(The Faculty of Fisheries, Kagoshima University)

Since 1950, the effective exploitation of the fishing ground of the East China Sea Region with the use of such fishing instruments as the coastal purse seine and the off-sea mackerel angling (pole & line) has made the ground one of the most important mackerel fishing grounds in Japan, producing about 30 per cent of the total mackerel catch amount in Japan.

The catch of this region consists of two kinds, one is *Scomber tapeinocephalus* (BLEEKER), the other is *Scomber japonicus* (HOTTUYN), the former forming majority catch, the latter, minority.

However, the variation in the resourses of mackerel in this region has been put under our vigilant watch, because the catch had the decreasing tendency in and after 1955. Meanwhile, the mackerel fisheries biological studies are launched with the investigation of Tsushima current[1], in which the clarification of the recruital-mechanism of mackerel population was proposed.

Therefore, the purpose of this study is the appreciation of reproductive potential of mackerel, which is the source of recruital-mechanism in this region, i.e., this can be reduced into the total amount of spawning egg.

For this purpose of estimating the total amount of spawing egg, the author has been trying to fix the amount with the maturity investigation method which consists in calculating the age composition of spawning groups, sex ratio, group maturity, number of intra-ovdrian eggs, and spawning rate, covering every spawning season and every spawning ground.

In this paper, the author is going to report the outline of the information as such itemes referred above.

The number of *Scomber tapeinocephalus* used as materials in this experiment is 1510, caught with the purse-seine and mackerel pole & line during January to July (1953–1960), the term which is supposed to be the spawning season in the East China Sea region. (See Fig. 1)

The author wishes to express a deep gratitude to Professor H. Aikawa and to Dr. H. Tsukahara of the Kyūshū University, for their encouragement and guidance given to the author while the present work was under progress. Thanks

are also due to the technicians in charge of Kagoshima Fisheries Experiment Station and Nagasaki Fisheries Experiment Station, who helped in performing the observations.

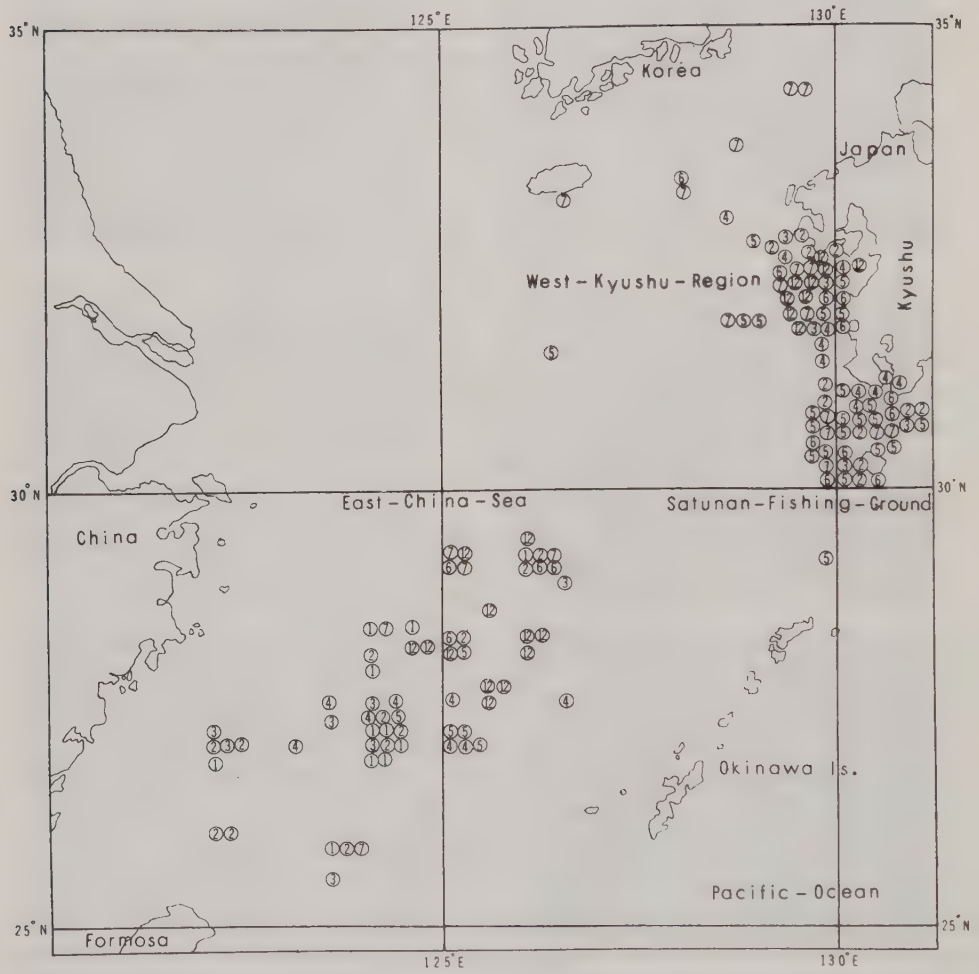


Fig. 1. Mackerel spawning ground in the East China Sea Region

I Sex Ratio

The number of the female of the mackerel amounts to 55 per cent of the whole, somewhat surpassing that of the male.

The monthly ratio is approximately equal with the exception of February, and no difference of sex ratio in the each age group is to be seen. (See Fig. 2)

According to the monthly variation of sex ratio in the each fishing ground, sex ratio of the East China Sea fishing ground is approximately equal, showing little monthly variation; but monthly sex-ratio between Kyūshū fishing ground and

Satsunan fishing ground shows converse correlation, and this is a rather interesting phenomenon, being a characteristic feature of mackerel spawning groups. (See Fig. 3)

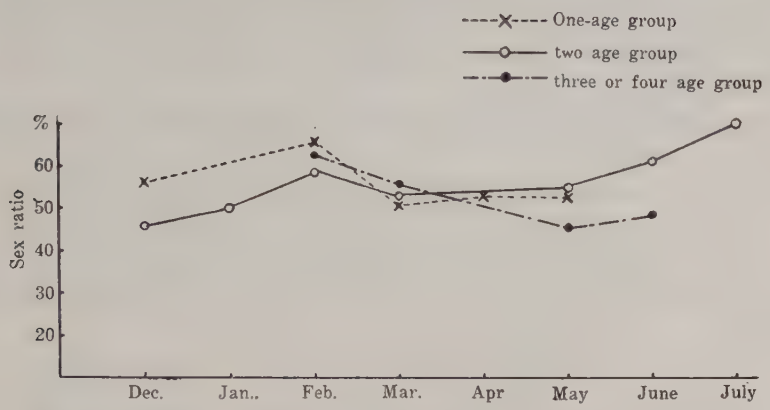


Fig. 2. Monthly variation of the sex ratio in each age group

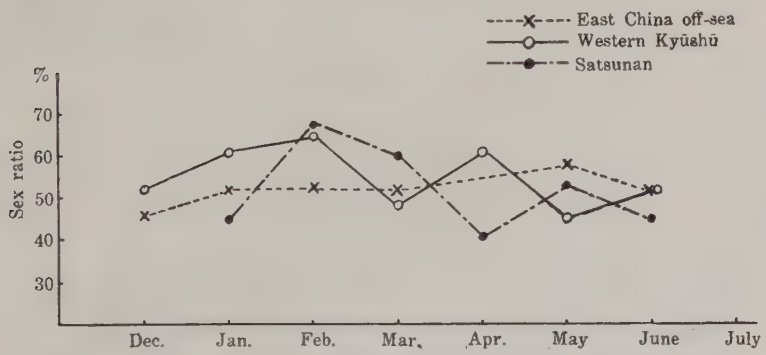


Fig. 3. Monthly variation of the sex in each fishing ground

II Group Maturity

Estimating from the view-point of the egg-diameter-frequency distribution of intra-ovarian eggs and from the result of histological survey, in case of one age group the ovarian of maturation stage can be observed in the ovarians having more than 10 g. weight, and in two age group, in those with more than 20 g. weight, and in three or four age group, in those with more than 30 g. weight, and in zero age group there is none observable.

Therefore, there can be found no functional spawning fish in zero age group, and only these over one age are functional as spawning groups, and then, the group maturity can be shown in the rate of number of the fish holding over standard-ovarian weight in each age group mentioned above.

Then, it is quite obvious that the group in possession of high group-maturity is nothing but the spawning group; the term in which this group migrates is the spawning season, and the locality in which this group migrates is the spawning ground.

According to the monthly variation of group-maturity in each age group, (See Fig. 4.) it is in the spring season, chiefly in April, that spawning can be observed in some part of one age group (more than 35 per cent), and in case of two age group (more than 70 per cent) the spawning can be seen from February to April, and in three or four age group (almost 100 per cent) it can be seen from February to May.

The spawning season of the old age group is earlier than that of the young age group, and extends over a long period such as from January to June.

According to the monthly variation of the group maturity in each fishing ground (see Fig. 5), the spawning in the coastal spawning ground is one or two months later, than that in the off-sea spawning ground, and the existence of special spawning group of various age groups in each fishing ground is to be supposed.

Fig. 4. Monthly variation of the rate of group maturity in each age group

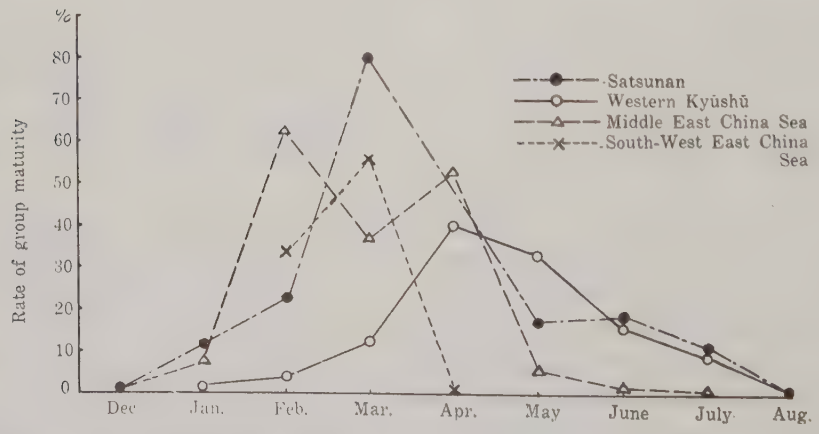


Fig. 5. Monthly variation of the rate of group maturity in each fishing ground

III Number of Intra-ovarian Eggs and Spawning Rate

The number of intra-ovarian eggs increases in accordance with the increase in ovarian weight (See Fig. 6.), and it increases with the increase of spawner's age in such figures as 33×10^4 in one age group, 33.6×10^4 in two age group and 48.3×10^4 in three age group (See Table 1), then within the same age group the larger fish have more number of eggs than the smaller ones.

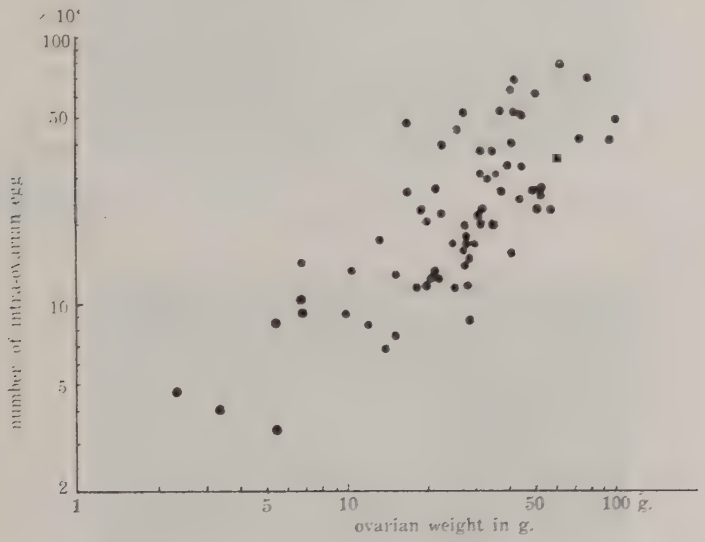


Fig. 6. Relation between the ovarian weight and the number of intra-ovarian egg

In the table the frequency distribution of intra-ovarian eggs is divided approximately into two, the one is non-modal type, omitting the immature egg group with the egg-diamater of under 0.2 mm, and the others are modal types.

Toward the spawning season, the number of the non-modal types decreases and the modal types increase, because some of the immature egg group belonging to the non-modal type become rapidly larger, and they are gradually divided into the uni-modal, the bi-modal and the tri-modal types. (See Table 2)

While, simply because there are three modes of the frequency distribution of intra-ovarian eggs, it does not always happen that the spawning is naturally to occur three times. In this connection, we can safely assume that a favourable environmental spawning condition might induce the fish, for example killifish to spawn with much frequency, while we should take into our consideration the existance of the collapse and absorption ovarian eggs as shown in S. Tateishi's observation[2] of *Cyprinus auratus* and *Scomber japonicus*. (See Plate 1)

But, generally speaking, spawning frequency of the old age groups whose spawning season is long, is supposed to be covering at least over three or four

Table 1. Number of the intra-ovarian egg in the each age group

age \ F.l. in mm		Number of the intra-ovarian egg $\times 10^4$		
		min.	max.	average
one-age-group	250~340	7	70	33
tow-age-group	340~390	12	76	33.6
three and four age-group	390<	15	85	48.3

Table 2. Seasonal composition of the egg-diameter-frequency-distribution type

age group \ Type \ Month		Dec.-Jan.	Feb.-Mar.	Apr.-May	Jun.-Jul.	Total
1	non-modal type	5	6	10	5	26
	uni-modal type		5	19		24
	bi-modal type			5		5
2	non-modal type	6	2	8	8	24
	uni-modal type		4	13	1	18
	bi-modal type		5	4		9
	tri-modal type		2	2		4
3, 4	non-modal type	5	4	5	3	17
	uni-modal type	1	7	5	3	16
	bi-modal type		1	2		3
	tri-modal type		2	1		3

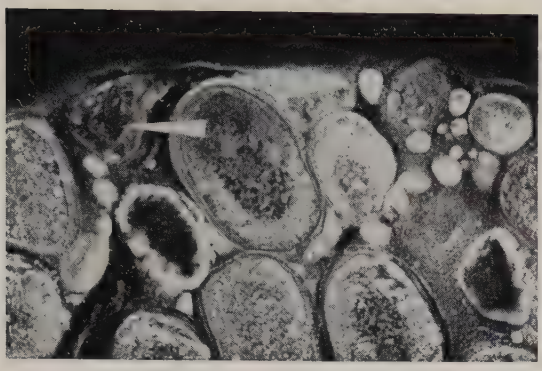
times. At present, to fix the clear-cut rate of the spawning in each age group the data, got monthly, of the rate of collapse eggs and apperance rate of new or old empty pollicle cell is put under the author's examination.

IV Age Composition of Spawning Group

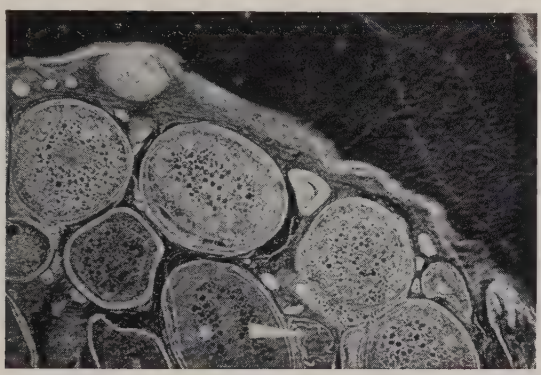
On the whole, the main part of spawning group consists of the two age group, they migrate in the southern spawning ground earlier than in the northern one.

In the spawning grounds of the Western Kyūshū fishing ground and of Satsunan fishing ground one age spawning groups are comparativily abundant, and in those regions the spawning of old-age group in May and June is worth noticing (See Fig. 7)

Plate 1. New empty follicle cell

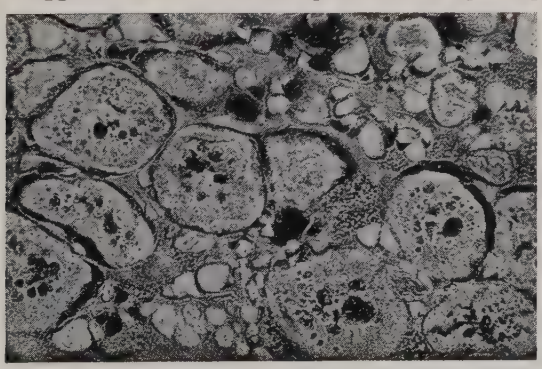


Fishing date: May 4, 1957, Fishing ground: Satsunan region
F. L.: 320 mm, Gonad weight: 24.5 g.



Fishing date: Apr. 17, 1957, Fishing ground: Satsunan region
F. L.: 327 mm, Gonad weight: 37.7 g.

Ovarian egg under advanced collapse and absorption process



Fishing date: May 7, 1957, Fishing ground: Satsunan region
F. L.: 290 mm, Gonad weight 18 g.

From the facts that the open-sea fishing is carried out with the mackerel pole & line, and the castal one is performed with the macherel purse seine. Selectibility of the fishing gear may play a part in fixing the size of the caught fish. But these age groups are supposed to be of the same race according to the data of the seasonal and local change of the age composition of the spawning groups. While, more thorough research is necessary for the more effective management of mackerel population in this region.

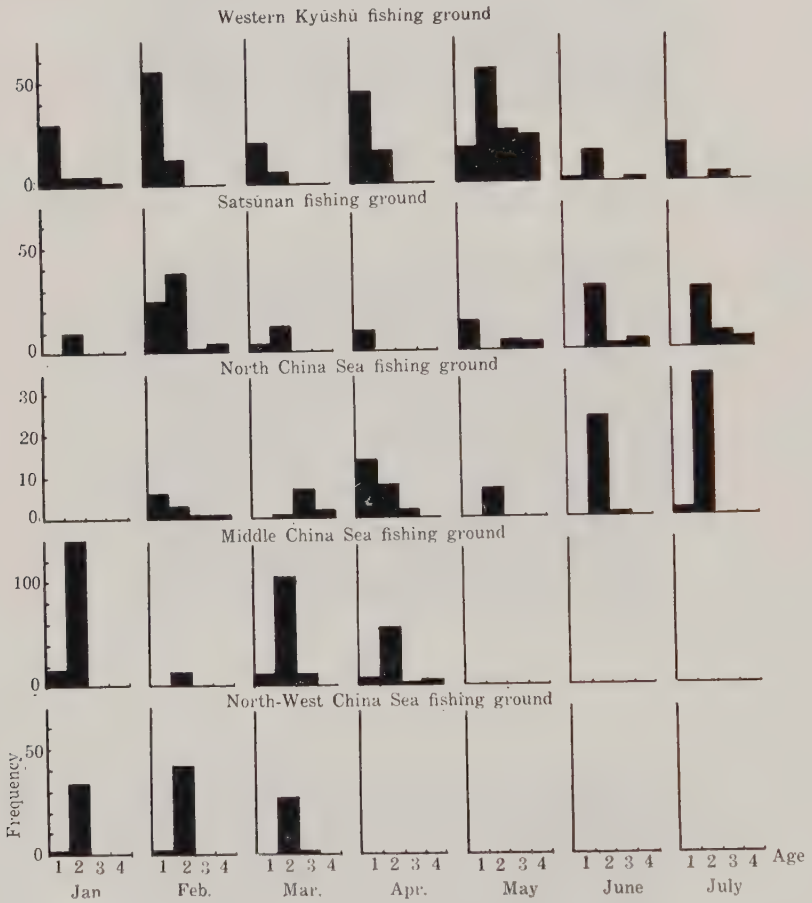


Fig. 7. Age frequency distribution of maturity and spawning season

Résumé

The author made some maturity investigation to solve the following equation on the spawning group of *Scomber tapeinocephalus* in the East China Sea region,

$$E = \Sigma\, Nx \cdot Sx \cdot Px \cdot ex \cdot \varrho x$$

Where, E is the actual total amount of eggs produced, i.e. the fecundity of

the mackerel population, Nx means the number of x-age group, Sx means sex ratio, Px means the group maturity of the female, ex means the number of the intra-ovarian eggs, and ♀x means the spawning rate of ripe eggs.

The results are sumarized as follows:

(1) the main part of spawning group is the two age group, and the catching intensification of purse seine in the costal spawning fishing grounds is worth noticing. (c.f. Fig. 7)

(2) the proportion of the females amounts to 55 per cent of the whole. (c.f. Figs. 2 and 3)

(3) the group maturity is estimated to be higher in the old age group than in the young age group. (c.f. Figs. 4 and 5)

(4) as is seen (3) the number of intra-ovarian eggs in each age group, is larger in the old age group than in the young age group. (c.f. Table 1).

(5) the mackerel spawning is the malitiple spawning, and the frequency of spawning rate of the old age group is estimated to be smaller than the young age group, but on this point, further study is necessary. (c.f. Table 2)

(6) hence, for the estimation of the mackerel fecundity in this region a cosoliclation of fisheries statistics complied from authentic sources is needed.

Literature

1. Fisheries Agency: The Development Investigation Report on the Tsushima Current, No. 1-5. 1957.
2. S. Tateishi: On the Lot of Unspawned eggs of *cyprinus auratus* LINNE, Bull. of the Faculty of Fisheries, Nagasaki University, No. 4, 1956.
3. S. Enami: A Consideration on the East China Sea Region Mackerel Fisheries, Memoirs of the Faculty of Fisheries, Kagoshima University, Vol. 8, 1960.

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March 1961

AGE AND GROWTH OF RED SEA BREAM, *EVYNNIS JAPONICA* TANAKA

By

Shin-ichi Mio

(Laboratory of Fisheries Faculty of Agriculture, Kyushu University)

For biological study of red sea bream *"Chidai", Evynnis japonca* TANAKA, 687 specimens were collected from the landings mostly caught by boat seine during the period from April, 1957 to October, 1959. Here, I wish to thank Professor H. AIKAWA, for his critical reading and commenting of preparing this paper.

I Age

The scales of ctenoid type are cleaned by putting in 5 percent solution of potassium hydroxide about 10 hours and then by washing well. The dried scales are prepared between the two slide glasses presented for observation.

The scale picture is of inflection type of ridges in both lateral sectors, but rather of concrescent type in the anterior sector. The marks are definable by ridges as distortion in both lateral and anterior sectors (Fig. 1). Scale-size (R) and mark-size (r) are measured on the longitudinal axis from the origin of growth (center of nucleus) by means of projector (magnified 20 times).

The relationship between (R) and (r)—*Similarity*—is examined for each scale groups taken from five different body portions respectively (Figs. 2 and 3). Although the *similarity* of mark-size is well recognizable in scales of every portion of the body, the probability of mark formation is 100 percent only among the scales taken from the portion D but less rather in the other portions, being 0.94 on an average. Many regenerated scales are present in every portion, but comparatively less in portion D. In addition, it is difficult to measure the mark-size exactly since scales are small in these portion except those in portion D and E (Tables 1 and 2).

Table 1. Rate of mark-formation in each portion

Portion/Mark	I	II	III	IV	Mean
A	1.00	0.94	0.80	0.95	0.92
B	1.00	0.82	0.88	0.95	0.91
C	0.97	0.80	0.88	0.95	0.90
D	1.00	1.00	1.00	1.00	1.00
E	1.00	1.00	1.00	0.95	0.99

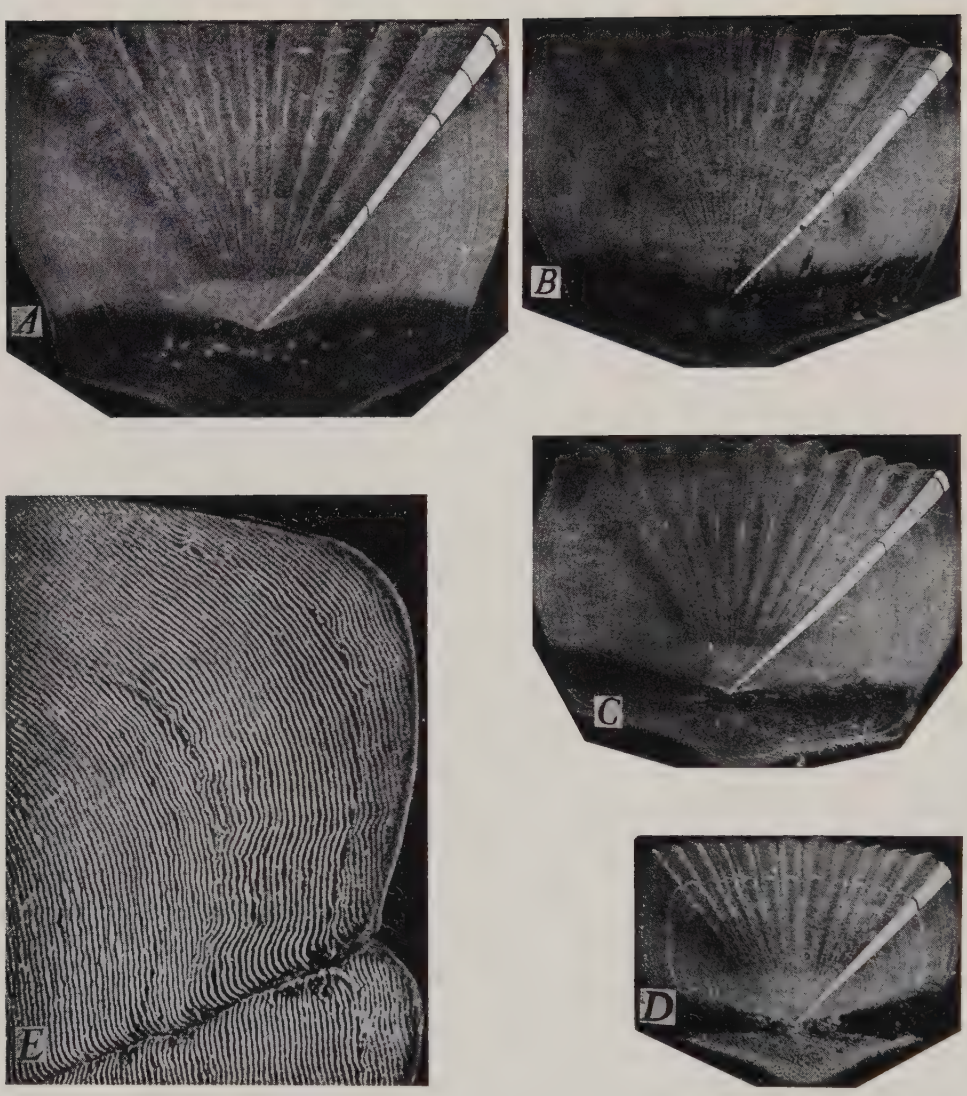

Fig. 1. Photograph of scales showing the marks and the measuring axis.

a. Four marks scale, F. L. 258 mm. May 5th 1957
b. Three marks scale, F. L. 244 mm. Feb. 2nd 1958
c. Two marks scale, F. L. 214 mm. Jun. 12th 1957
d. One mark scale, F. L. 135 mm. Jun. 6th 1957
e. Antero-lateral view of the mark

Relationship of fork length (L) to scale-size (R) is approximately expressed by the equation (1) with considerable variation of plotting of (R) against (L) (Fig. 4).

$$\hat{L}=e^{0.338}\hat{R}^{0.456} \quad \cdots\cdots (1)$$

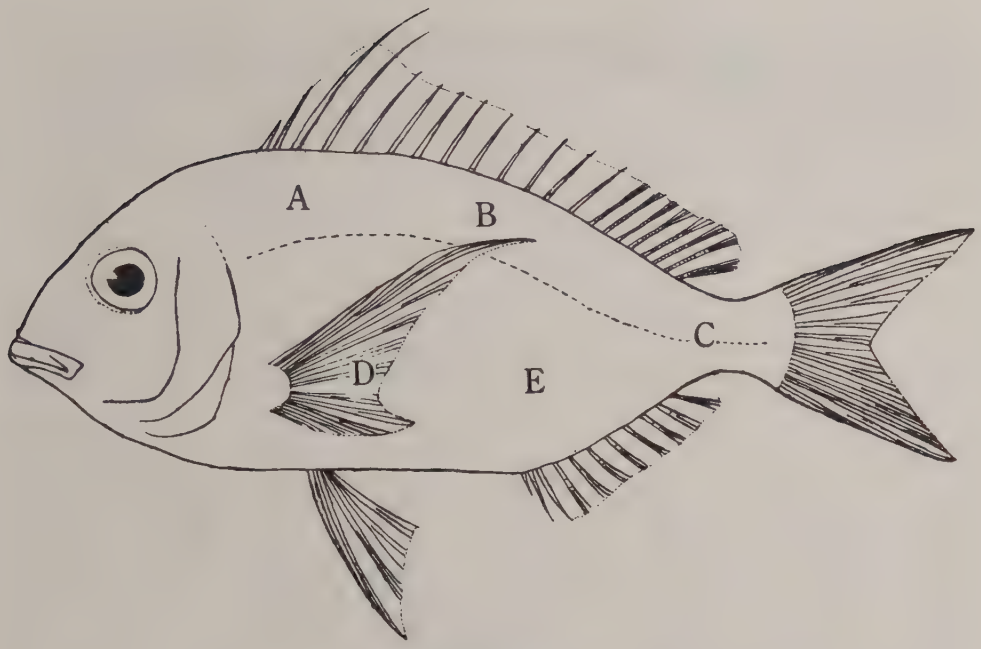

Fig. 2. Body portions in which scales were collected

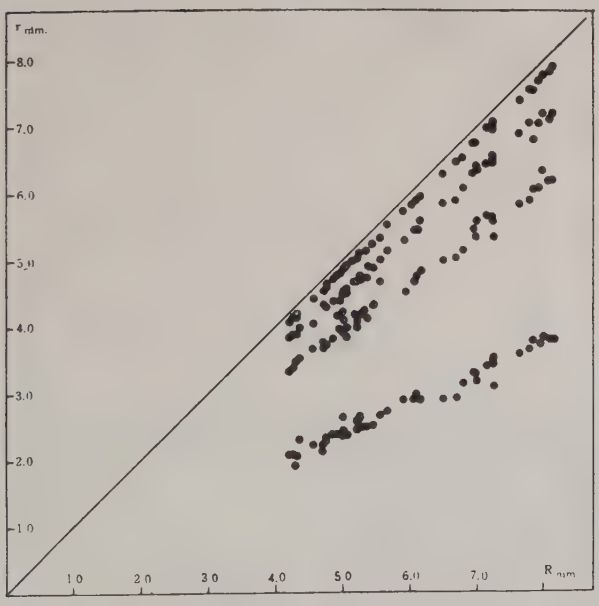

Fig. 3. Similarity of mark size

Table 2. Rate of mark-size fallen in the range of standard deviation (δ) by portion

Portion/Mark	I	II	III	IV	Mean
A	0.90	0.73	0.77	0.90	0.83
B	0.78	0.88	0.79	0.53	0.77
C	0.66	0.86	0.80	0.57	0.72
D	0.90	0.82	0.75	0.95	0.86
E	0.80	0.78	0.82	0.68	0.77

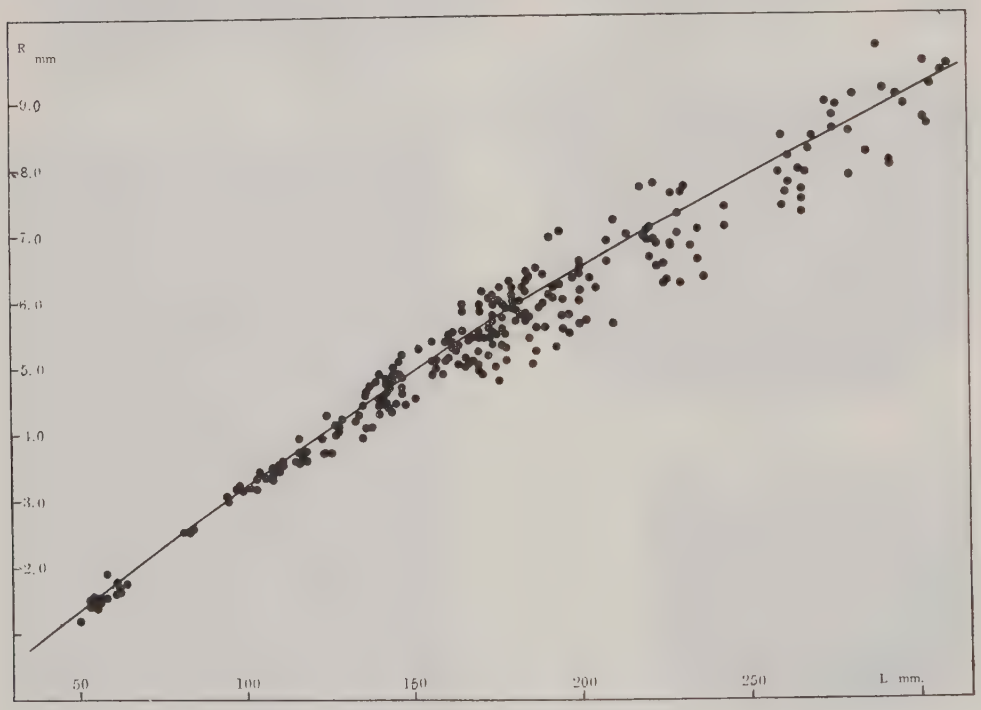

Fig. 4. Relationship of fork length to scale

(R) and (r) measurements are standardized by multipling with factor, $\hat{R}/R$, since the similarity is recognizable as mentioned above. Sampling of specimens will be accompanied inevitably by following two errors: (a) the young fish is sampled in larger numbers than the old one; (b) the same relationship in *similarity* appears in the relationship of the fork length to mark-size in the same age group. The relationship of standardized mark-size to fork length —Correspondency—is expressed linearly (Table 3).

Lastly, following Walford's graphic method the following equation is obtained,

$$r_{n+1}=0.708\ r_n+2.89 \quad \ldots\ldots (2)$$

Then, these marks are formed at the same time-interval. The values of $R-r_1/R$ and of $R-r_n/r_n-r_{n-1}=\alpha$ change seasonally, attaining the minimum

Table 3. Modes of standard mark-size in season and each interval of fork-length

Season	Mode of fork-length	r_1 mm.	r_2 mm.	r_3 mm.	r_4 mm.	r_5 mm.
Mar.	136	3.88				
—	191	3.75	5.62			
	236	3.88	6.12	7.12		
May	266	3.88	5.62	6.88	7.62	
Jun.	141	3.88				
—	196	3.88	5.88			
Aug.	231	3.88	6.12	6.88		
Sep.	126	3.25				
—	181	3.62	5.62			
	251	3.88	5.88	6.62	7.62	
Nov.	276	3.62	5.38	6.62	7.88	—
Dec.	131	4.12				
	161	3.62	5.12			
—	226	3.75	5.62	6.88		
	261	3.62	5.50	6.88	7.75	
Feb.	291	3.88	5.62	6.88	7.75	8.38
Mean		3.88	5.62	6.88	7.75	8.38
l		121	178	220	251	274

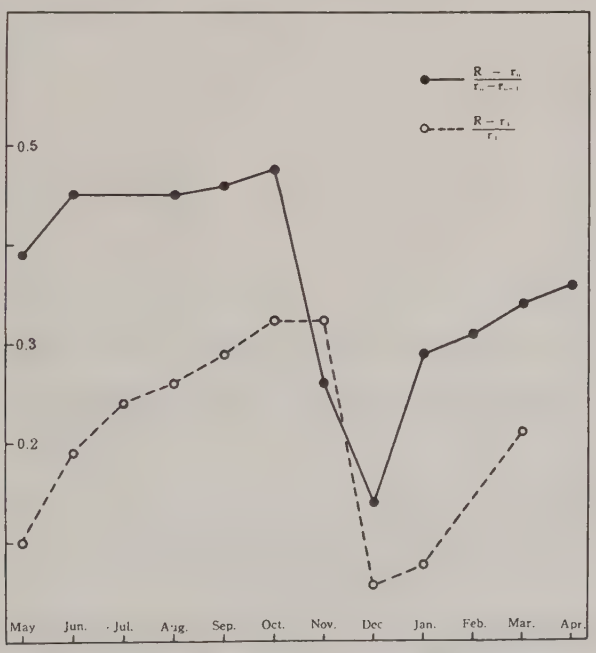

Fig. 5. Monthly changes of marginal growth index $R-r_n/r_n-r_{n-1}$, $R-r_1/r_1$

value in December. The mark is formed in this month of every year. The fork length, l_n, when the n-th mark is just formed in December, is computed by the equation (1).

II Growth

The sizes of fork length, l, obtained by the scale method are tested by Walford's graphic method and expressed by a equation as below;

$$l_{n+1} = 0.735 l_n + 90 \quad \cdots\cdots (3)$$

The main spawning season is considered in October (Fig. 5). Here, l_n, the

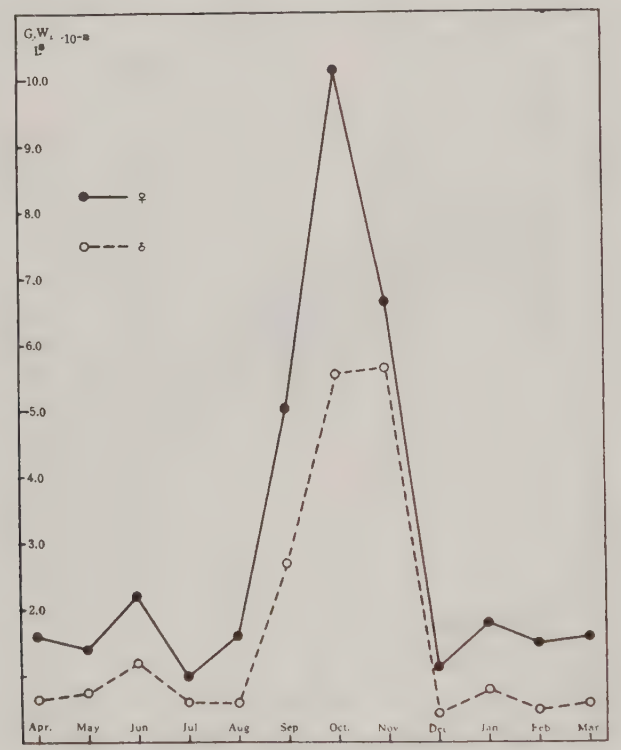

Fig. 6. Monthly changes of maturity index, G. W./L³

first mark just formed is not attained in December of 0-age but in these months of 1-age. Thus, putting t=0 at the spawning time, the growth in length (L) is given as,

$$L_t = 340(1 - e^{-0.308t - 0.068}) \quad \cdots\cdots (4)$$

where L is the fork length at t years since spawned.

Relationship of the body weight (W) to the fork length is given approximately as,

$$W = 2.36 \cdot 10^{2} \cdot L^{3} \quad \cdots\cdots (5)$$

Hence, the growth of body weight is derived from the equation (4).

$$W_t = 928(1 - e^{-0.308t - 0.068})^{3} \quad \cdots\cdots (6)$$

where the time of the maximum growth rate (T) is 3.34 years (L_T: 227 mm. W_T: 277 g.).

Table 4. Fork-length and body weight at t years since spawned

t	*L* *Lt.* mm.	*W* *Wt.* g.
1	107	28
2	168	112
3	214	231
4	248	358
5	272	474
6	292	576

Literature

(1) Takeshita, K: Records of Oceanographic Works in Japan, special number 3 1959.
(2) Mio, S: Records of Oceanographic Works in Japan, Vol. 5 No. 2, 1960, p. 79–85.
(3) Mio, S: Records of Oceanographic Works in Japan, Vol. 5 No. 2, 1960, p. 86–97.

Records of Oceanographic Works
in Japan (Special Number 5)
March 1961

AGE AND GROWTH OF FLATFISH, GANZŌ-BIRAME, *PSEUDORHOMBUS CINNAMONEUS* (TEMMINCK et SCHLEGEL)

By
Syūhei Matsuura
(Fisheries Laboratory, Faculty of Agriculture, Kyushu University)

Pseudorhombus cinnamoneus (T. & S.) is landed in all seasons in the coastal region, Chikuzenkai, Fukuoka Prefecture and is one of the important bottom-fishes economically. This report is on the determination of age and growth of flatfish, Ganzō-birame, *P. cinnamoneus* (T. & S.). The otoliths have been used for age-determination. The author wishes to express Professor H. Aikawa a deep appreciation for his cooperation in the preparation of this paper.

Age-determination from Otolith Method

1. Material and method

Material, about 400 specimens, has been collected from March, 1958 to May, 1960 on Chikuzenkai region near Fukuoka, from landings by gill-net, seine and line. The sample fishes were weighed and measured in the total length. For otolith reading the longitudinal sections cut on the minor axis through the center are prepared. For preparating the section, otolith is imbedded in acrylic resin and ground with electric grinder. Immediately after the specimen is measured on the meristic characters, samples of otoliths are taken out and cleaned with finger work. Minor axis through the exact position of the center of the otolith is marked on the dried sample with pencil or pen and ink, since the center of the otolith is definable. The otolith is lifted with forceps and placed carefully to stand vertically in the transparent acrylic resin in the pharmacopoeial capsule while the resin is in the state of half-polymerization. The otolith samples were left for a few hours in the capsules until the resin had polymerized completely, then ground from both sides to the center of otolith with electric grinding machine to obtain the part of otolith marked before imbedding. The grinding is started from one end of otolith continued up to this mark and a piece of the other end is also ground down using temporary stopping to make finger work easier. Thus otolith sections are prepared through the middle of otolith thin enough to fix on slide glass (Ca. 0.2–0.5 mm.). After this section is washed with water and dried well, it is mounted with Canada balsam on the slide glass.

2. Otolith reading

The marks of the otolith are read by using a projector at 50 times magnification. The otolith section is made up with both transparent and opaque zones

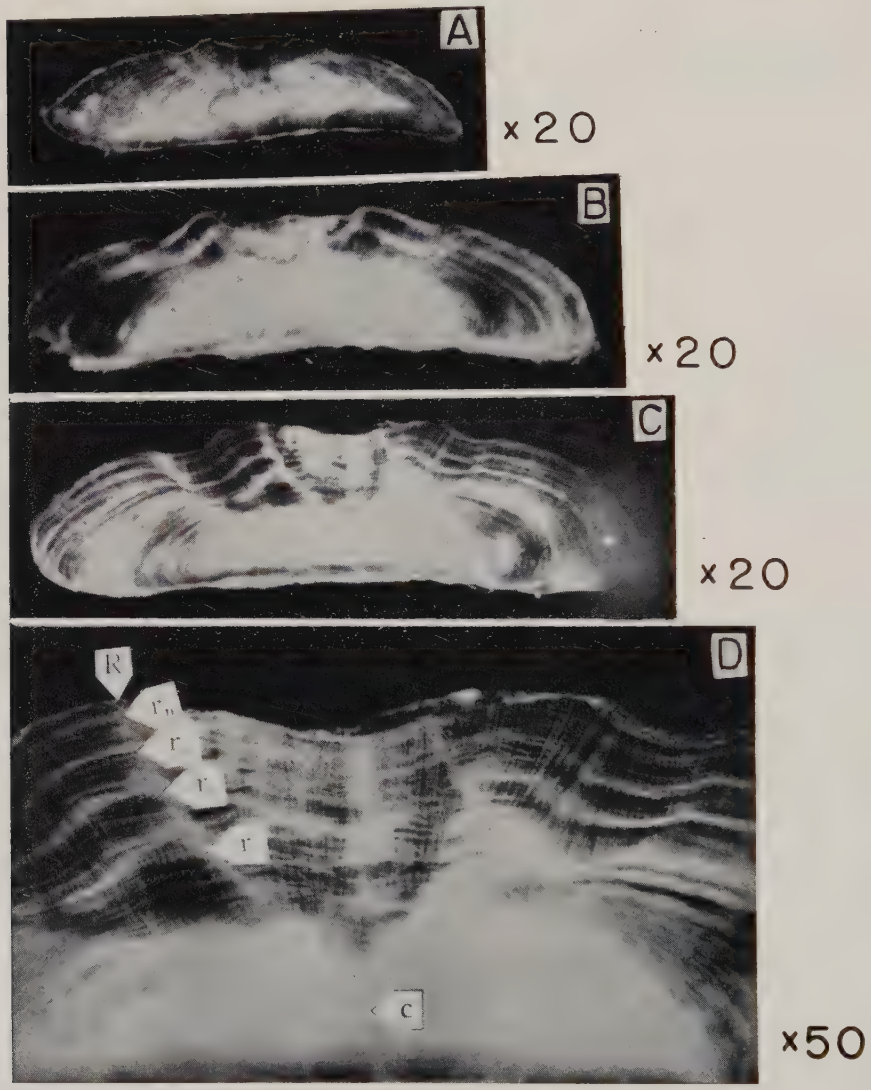

Fig. 1. Otolith of *Pseudorhombus cinnamoneus* (TEMMINCK et SCHLEGEL)

A. Otolith from fish 188 mm., caught in May. No mark presents.
B. Otolith from fish 243 mm., caught in May. r_2-mark presents.
C. Otolith from fish 320 mm., caught in October. r_4-mark presents.
D. Otolith from fish 320 mm., caught in October, to show the detail of the annuli. r_4-mark presents.

Note: C ..... center of the otolith
r_n ..... mark size
R ..... otolith size

alternately over opaque central portion. These zones form a concentric circle from the center of the otolith, and are somewhat invisible in the ventral sector. Measuring axes are definable as contour of a fault plane of V-shaped in the lateral sector of the otolith. Mark sizes, r_n, are measured as the innermost contours of the opaque zones (see Fig. 1–D).

3. Relationships of total length to otolith size

Relationship of otolith size, R, with the total length, L, is expressed by following two different equations (see Fig. 2);

$$R = 2.68 \times 10^{-3} L \qquad L \leqq 276.8 \text{ mm.} \quad R \leqq 0.742 \text{ mm.} \ldots\ldots (1)$$

$$R = 4.53 \times 10^{-3} L - 0.512 \qquad L > 276.8 \text{ mm.} \quad R > 0.742 \text{ mm.} \ldots\ldots (2)$$

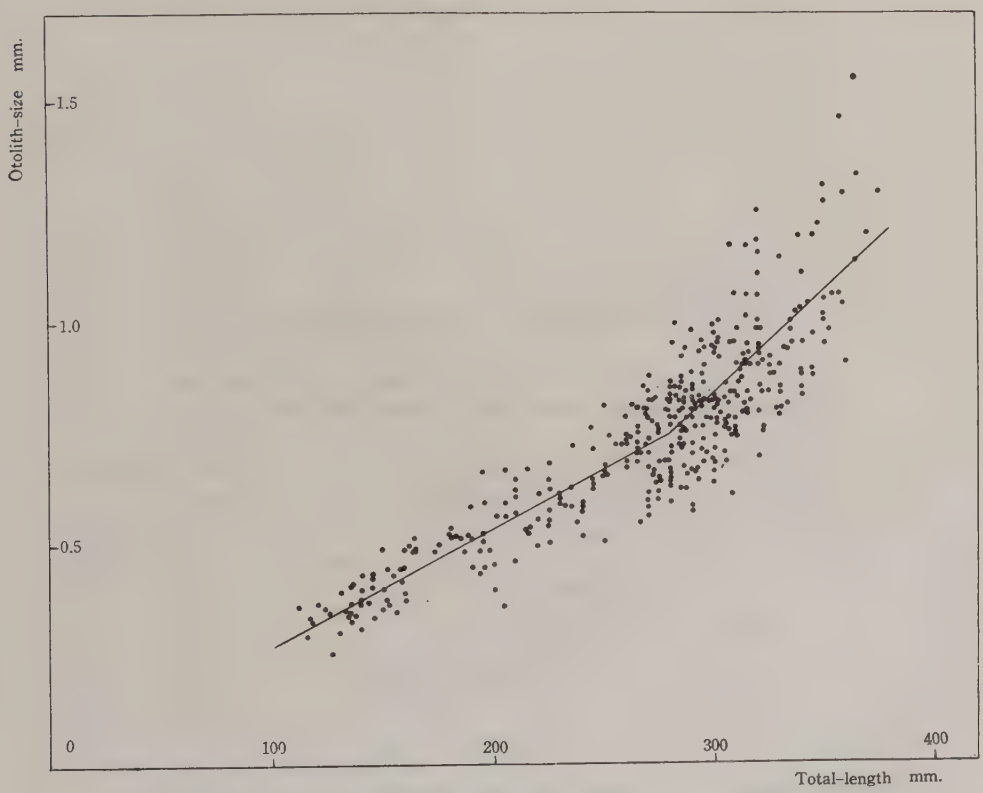

Fig. 2. Relationships of otolith size to total length

Both right and left otoliths are equal in the probability of mark-formation, but the otolith size, and the mark sizes, are different with each other, so in this study the right otoliths are used to show the relationships of total length to otolith size.

4. Examination of similarity in the mark sizes of the otolith

Relationship of otolith size with the mark size examined with 29 specimens (260–289 mm. in total length, caught for the months from April to June) is

expressed approximately in a linear regression though with considerable large variations in the large size group. Similarity of mark size is always found in fishes caught in any season of a year (see Fig. 3, Tab. 1).

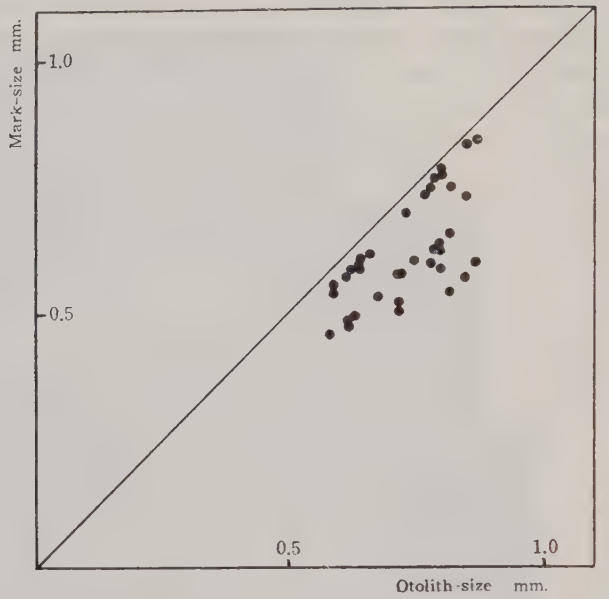

Fig. 3. Similarity of r_n to R based on 29 specimens, 260–289 mm. in total length, in 3 months from April to June

Table 1. Probability of mark formation based on 29 specimens, 260–289 mm. in total length, caught in 3 months from April to June

Mark number		r_1	r_2
Numbers of specimens	with mark	18	17
	omission	11	12
	with duplicate marks	1	1
Rate of mark-formation (%)		62	59

5. Standardization of the mark size and the test of correspondency

Standard otolith sizes, $\hat{R}$, are derived from equation (1) and (2). Standard mark sizes, $\hat{r}_n$, are obtained by correcting the measurement of the otolish

Table 2. Mark size (r_n) and intermediate length (l_n) and intermediate weight (w_n) obtained from otolith method

r_n (mm.)	0.584	0.705	0.825	0.922	1.005
l_n (mm.)	218.1	263.3	295.1	316.6	334.9
w_n (g.)	116.0	204.4	287.7	355.4	420.7

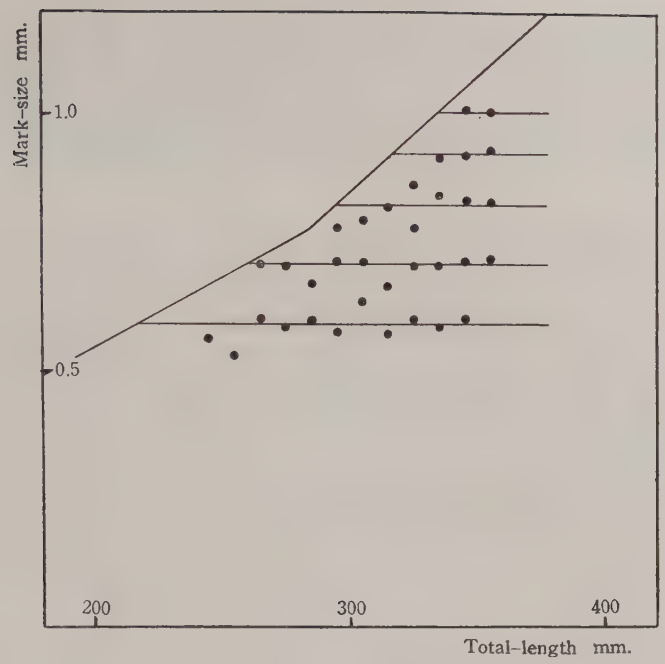

Fig. 4. Correspondency of mark size to total length

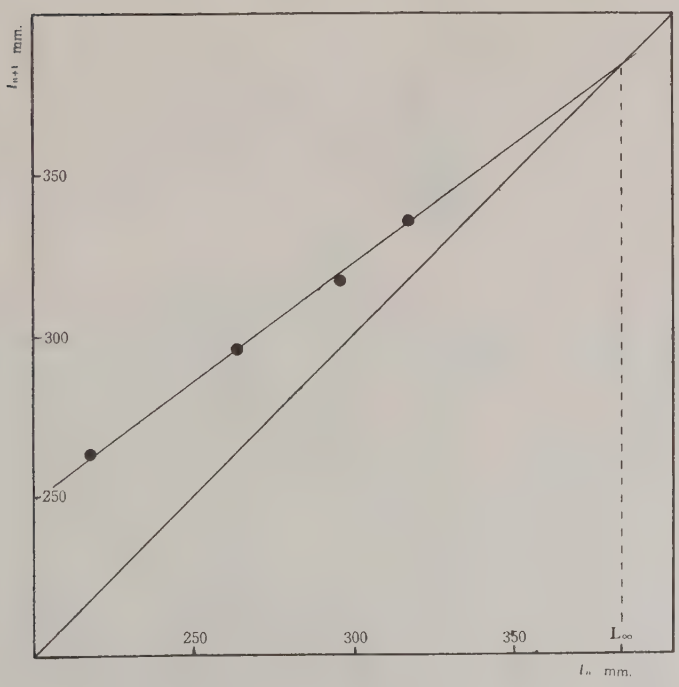

Fig. 5. Walford's growth transformation of total length

size, R, and mark sizes, r_n, with the factor of $r_n \times \frac{R}{\hat{R}}$ because the similarity is recognizable as mentioned above. For each different size group in every 10 millimeter unit, relationship between modes of standardized mark size and total length is expressed linearly, that is the correspondency of mark size (see Fig. 4, Tab. 2)

6. Walford's plots of growth

The intermediate length, l_n, namely, the length at the season of mark formation is derived from modes of $\hat{r}_n$ applied to equation (1) and (2). By Walford's graphic method with total length represented along both the x-axis and along the y-axis, plot l_n on the x-axis against l_{n+1}, respectively, on the y-axis (see Fig. 5). These points fall along a straight line, showing transformation of growth, given by a following equation;

$$l_{n+1}=0.732\, l_n+102.9 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

From this one can recognize that the growth increments are corresponded to the equal time intervals. The ultimate length (l_∞) is given by a point of intersection with a line drawn at 45° through the zero point ($l_\infty = 384$ mm.).

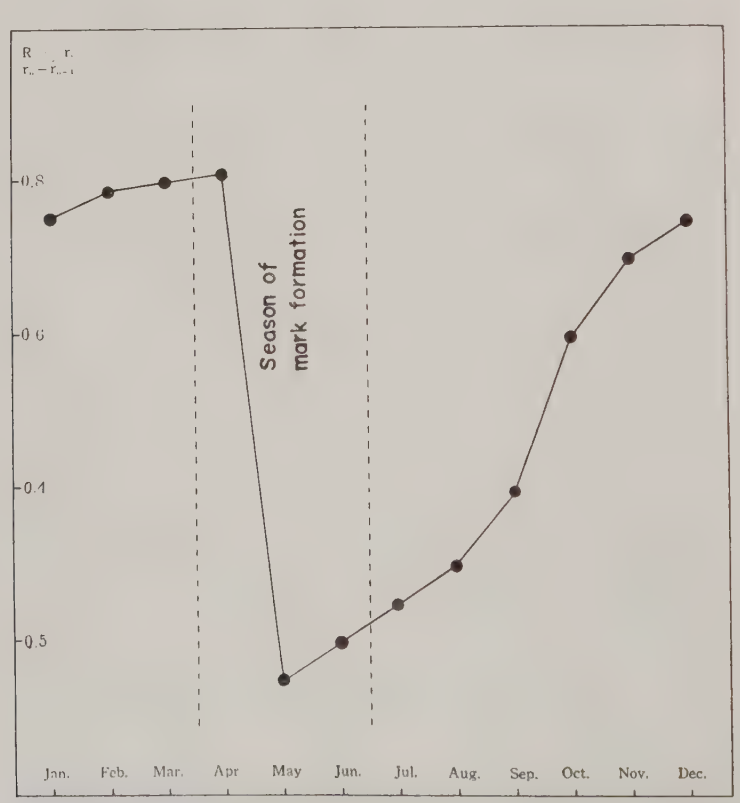

Fig. 6. Monthly changes of growth rate of marginal region of otolith

7. Period of mark-formation and spawning season

The period of the mark-formation is estimated from monthly changes of marginal increment, namely, $(R-r_n) / (r_n-r_{n-1})$. Marginal increment shows minimum value in May (see Fig. 6). The height of spawning season is considered from late in October to early in November from monthly changes of maturity index, G. W./L^3, (see Fig. 7).

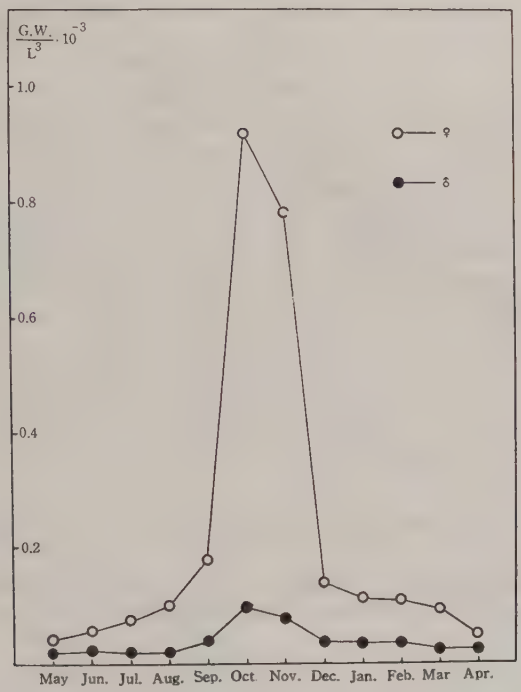

Fig. 7. Monthly changes of gonad index

Growth

The first mark (r_1) is just formed in the 1.5 years old fish. Putting t=0 at the spawning time, and applying l_n to the equation of growth which has been derived by Pütter-von-Bertalanffy, the total length at t years after the fish spawned is shown by the next expression;

$$L_t = 384(1-e^{-0.311\,t-0.346}) \quad \cdots\cdots (4)$$

Relationship of total length to body weight is given as (Fig. 8);

$$W = 1.12\times10^{-2}\,L^3 \quad \cdots\cdots (5)$$

and the growth of body weight is formularized by the following equation;

$$W_t = 634(1-e^{-0.311\,t-0.346})^3 \quad \cdots\cdots (6)$$

From this equation the period of maximum growth rate, T, is obtained as 2.42 years (L_T=256.2 mm., W_T=188.4 g.) (Tab. 3).

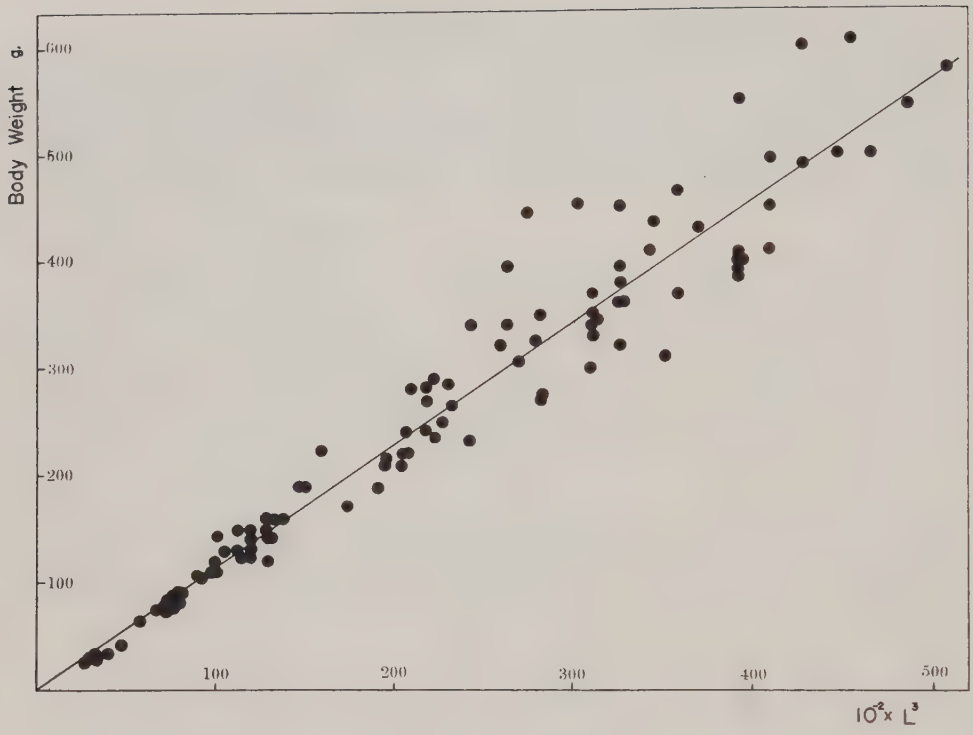

Fig. 8. Relationship of (total length)^3 to body weight

Table 3. Total length and body weight at t years after spawning calculated from Pütter-von-Bertalanffy's and Buch-Andresen-Fisher's equations

t (year)	1	2	3	4	5	T=2.42
L_t (mm.)	184.9	238.2	277.1	305.7	326.6	256.2
W_t (g.)	70.8	151.3	238.4	320.0	390.3	188.4

Literature

(1) Takeshita, K: Records of Oceanographic Works in Japan, special number 3 1959.
(2) Mio, S: Records of Oceanographic Works in Japan, Vol. 5 No. 2, 1960, p. 79–85.
(3) Mio, S: Records of Oceanographic Works in Japan, Vol. 5 No. 2, 1960, p. 86–97.

Records of Oceanographic Works
in Japan (Special Number 5)
March 1961

ON THE AGE AND GROWTH OF *CHELIDONICHTHYS KUMU* (LESSON et GARNOT)

By

Yohiko Yunokawa

(Fishery Laboratory, Faculty of Agriculture, Kyushu University)

The sea-robin, *Chelidonichthys kumu,* inhabits warm waters. The commercial catch is the largest in the Yellow sea and the East China sea, and the sea-robin is economically important bottom fish in their fishing grounds.

Our group has been investigating the relation between the coastal bottom fish community and the oceanic bottom fish community. This investigation was practised as a link of these, too. The coastal and oceanic materials of the sea-robin were treated separately, and I report the result of coastal materials. About 400 specimens had been collected over two years since March, 1958, in near waters from Hakata Bay to Karatsu Bay.

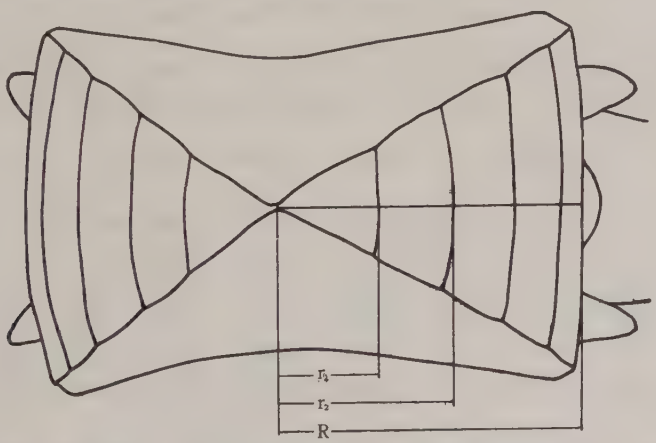

Fig. 1. The measuring axis of the vertebra

The characters used for determining age consist of scale, otolith, vertebra and others, but in the sea-robin the vertebra is the most preferable of them for this purpose. After measuring total length, body weight, gonad weight etc, the vertebrae are soaked in 5% sodium hydroxide for a day, and then they are washed a little and when they are soaked in phenolphthalein solution, they are dyed red in order to observe marks easily. The centrum is magnified twenty times by projector, and mark size is measured. It was examined whether marks of centrum could be practically used or not as a character for determining age. The marks of centrums were regular and similar (Fig. 2), and so we can use them for age determination.

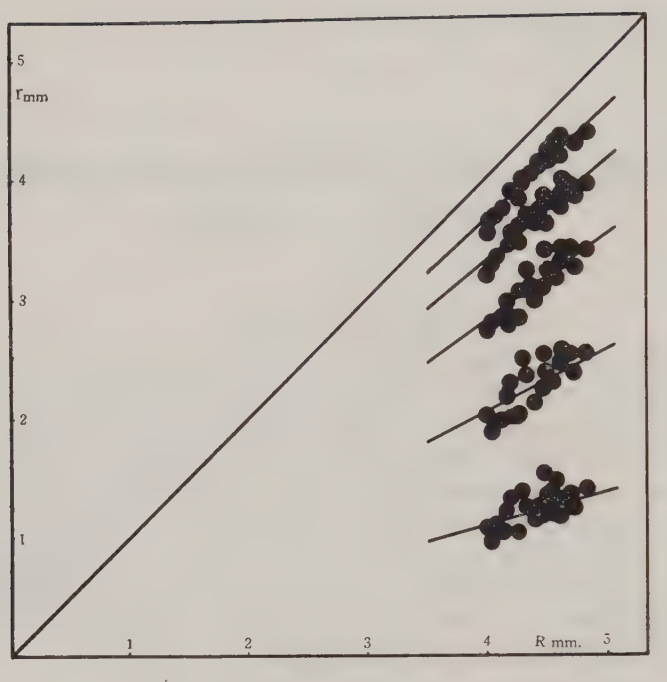

Fig. 2. Similarity of mark size

The number of vertebrae is 33 to 36, most of them are 34. Table 1 shows approximate probability of mark formation in each range of vertebral number,

Table 1. Probability of mark formation

Vertebral number / Mark	1 – 4	5 – 8	9 – 12	13 – 16	17 – 20	21 – 24	25 – 28	29 – 32	33 –
r_1	0.56	0.66	0.73	0.73	0.67	0.68	0.66	0.48	0.20
r_2	0.53	0.70	0.77	0.77	0.71	0.72	0.70	0.51	0.21
r_3	0.59	0.78	0.85	0.85	0.79	0.80	0.78	0.56	0.23
r_4	0.56	0.75	0.81	0.81	0.76	0.77	0.75	0.54	0.22

and the vertebrae of 9th to 16th has high probability. We are often afraid of mistaking real marks for imitation marks and erring in measuring mark size, but we must avoid these errors. For that reason, the vertebrae of 9th to 11th are always selected and only marks commonly existed in these are observed as real marks; when mark size is measured, the 10th centrum is used.

The relation between centrum size R, and total length L, (Fig. 3) is

$$\hat{R} = 0.11\,\hat{L} - 0.11$$

There are variations in centrum sizes of the same total length. Therefore, all mark sizes measured must be corrected to standard centrum sizes, that is, $r_1, r_2, r_3 \ldots = \hat{R}/R \times r'_1, r'_2, r'_3, \ldots$, where r_1, r_2, r_3, are mark sizes corrected, $\hat{R}$ is standard centrum size, $r_1, r_2, r_3, \ldots$ are mark sizes measured and R is

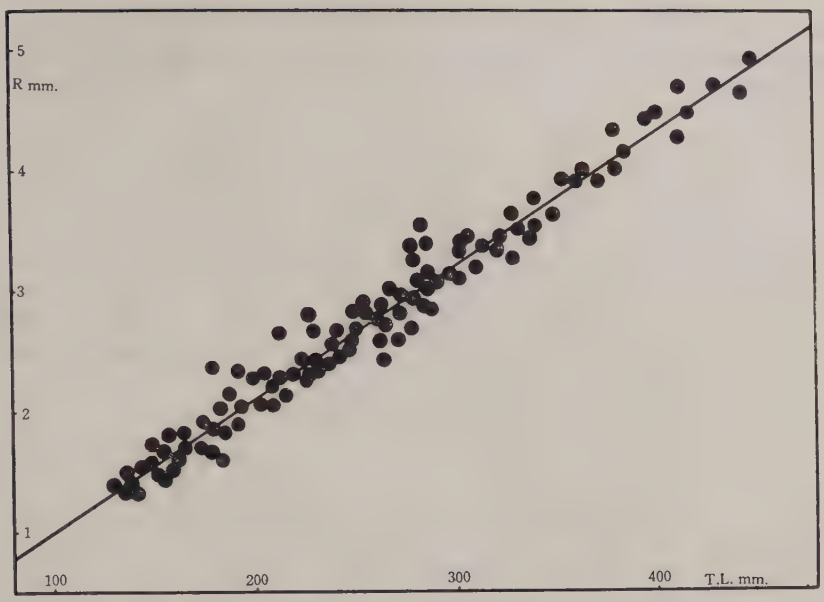

Fig. 3. Relationship of mark size to total length

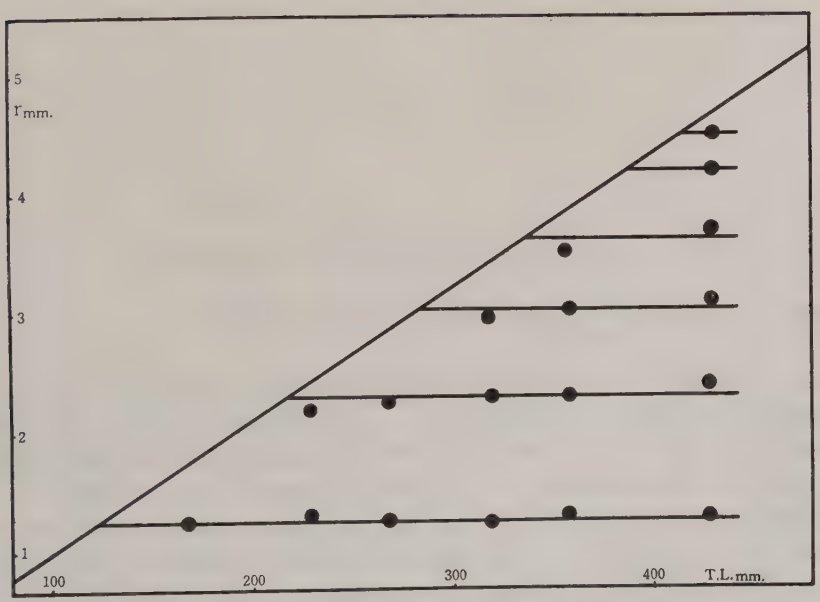

Fig. 4. Correspondency of mark size to total length

centrum size measured. All mark sizes in Table 2 are modes in each range of total length.

By means of Walford's growth transformation method, r_1, r_2, r_3, ... r_n are plotted along the x-axis against r_2, r_3, r_4, ... r_{n+1} along the y-axis. Their points

Table 2. Mark size in each range of total length

Range of total length	r_1	r_2	r_3	r_4	r_5	r_6
100 – 190	1.21					
191 – 232	1.28	2.14				
233 – 286	1.25	2.18				
287 – 340	1.21	2.23	2.85			
341 – 380	1.29	2.23	3.08	3.45		
381 –	1.30	2.62	3.16	3.78	4.20	4.50
Mean	1.24	2.28	3.03	3.62	4.20	4.50
ln (mm)	122	215	283	336	388	415

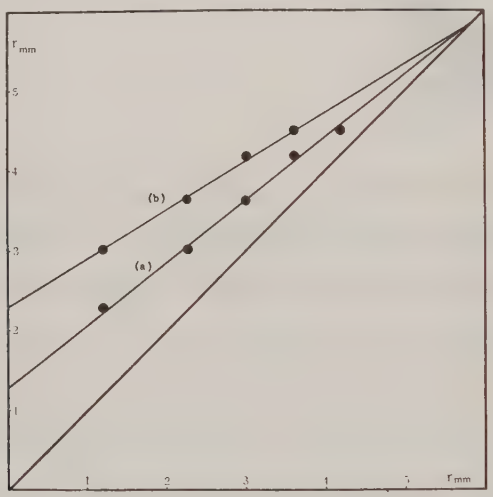

Fig. 5. Walford's growth transformation of mark size

fell along an approximate straight line (Fig. 5(a)), which is

$$r_{n+1} = 0.781\, r_n + 1.310$$

The ultimate length r_∞ can be located graphically at the point where the length at n equals the length at n+1, that is, $r_\infty = 1.310/1 - 0.781 = 5.98$. The ultimate total length L_∞ at r_∞ is 548.3 mm. The relationship of the total length to body weight is $W = 1.099 \cdot 10^{-2} \cdot L^3$, the ultimate weight W_∞ is 1808 g.

To seek for the period when the mark is formed, the ratio of marginal growth increment, $R - r_{n+1} / r_{n+1} - r_n$, was calculated monthly (Fig. 6). According to this, the points fall down in March and September, and so it is estimated that the mark is formed two times in a year, March and September.

When mark sizes at age 1, 2, 3, ... $t+1$, $r_{n+1} = 0.610\, r_n + 2.333$ (Fig. 5(b)).

Considering growth of young stage, 1st mark is formed at one age. Spawning peak of the sea-robin can be fitted to Pütter-Bertalanff's equation and in weight Buch-Andressen-Fischer's equation

$$L_t = 548.2\,(1 - e^{-0.494\,t + 0.256})$$

$$W_t = 1808\ (1 - e^{-0.494\,t + 0.256})^3$$

Total length and body weight in Table 3 was calculated by these equations.

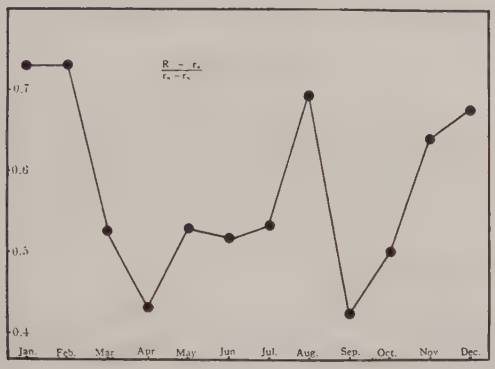

Fig. 6. Monthly change of marginal growth rate of vertebra

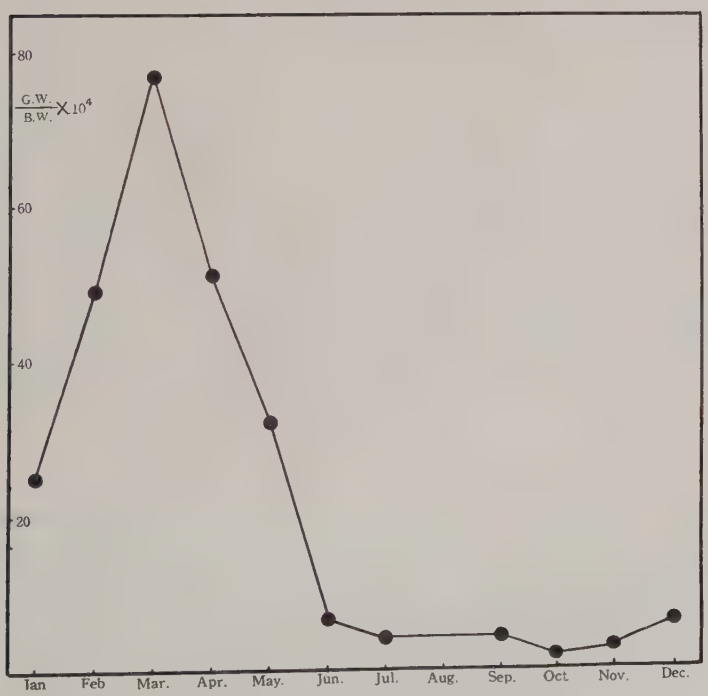

Fig. 7. Monthly change of maturity index

Table 3. Total length and body weight at each age

Age	1	2	3	4	5
T. L. (mm)	116	285	387	450	488
B. W. (g)	18	263	664	1040	1329

Discussion

The time when increasing velocity in weight is maximum, $d^2w/dt^2=0$, is 2.74 years. The 0.74 years is December and this month is early spawning season. In full two years, most of them join a spawning group, because the sea-robin of the total length more than 250 mm has eggs completely mature, or mature eggs.

In coastal sea waters, young age group is mainly catched. The statistical data which show the distribution of total length in landings are absent, but according to my samples and observation of landings one age group less than 200 mm in total length is catched in summer, two and three age groups are mainly catched in winter, and young groups less than 3 age occupy the greater part of the landing in other seasons.

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BIOLOGY OF THE CUTLASSFISH, *TRICHIURUS LEPTURUS LINNAEUS*

Part 1. Early Life History

By

Hiroshi Tsukahara

(Fisheries Laboratory, Faculty of Agriculture, Kyushu University)

The cutlassfish or ribbon fish, *Trichiurus lepturus* LINNAEUS, konwn as "Tachi-uo" in Japan, is one of the most important fishes from the economic view point native to the Yellow and the China Sea. This fish occurs generally about middle part of Japan and Southward. The recent annual landings of this species in Japan reached from 20,000 to 30,000 tons and have shown a relatively steady increase. The majority of landings is taken in Kyushu Province and the fishing is carried on almost exclusively by the trowler and bulltrowler. On the other hand, the cutlassfish is known to occur in the coastal waters of Kyushu and the fishermen take them mainly on hook and line. They are generally ranked with the better food fishes of the Ariake Sound and are most important for the fishermen of Yushima Island.

Several published materials on fishery biology of this fish of the open sea stock already exist. However, up to the present time, there has been a notable lack of the knowledge regarding the coastal stock, particularly with regard to intermingle of the both stock. The present report is part of an extensive investigation of the cutlassfish and summarizes one phase of the life history in the Ariake Sound. The study was made mainly in Amakusa Marine Biological Laboratory, Faculty of Science, Kyushu University, situated in Amakusa Islands; various members of the Laboratory staff helped in collecting the material, and their assistance is gratefully acknowledged.

Egg and Embryological Development

Material and method

The eggs and larvae of the cutlassfish have been described from material collected in plankton or larvae tows by Kamiya (1922), Delsman (1926) and Uchida (1933), but until now there has been no record of the artificially fertilized eggs of this fish. The eggs and larvae were obtained in the Ariake Sound by means of conical net with the opening attached to iron-ring of 1 m. in diameter for the macroplankton. The hauls were made horizontally or vertically at slow speed. In addition, the effort was made to find the fishes with gonad at full

maturity and the ripe adults were obtained from an area within a few miles of Yushima Island by hand line. These fishes gravid with eggs are visibly distended in belly and are sufficient to make clear the appearance of a mature ovary and of the ripe eggs contained therein and yield a stream of transparent mature eggs under slight stripping pressure. Male fish ripe with sex product yield milt on stripping, and those from which milt flows with slight pressure can be considered as in the spawning condition. The spawning season occurs from July to August and the peak is in July. The eggs were stripped and inseminated with the milt from the ripe male into a glass jar and were stirred gently in order to facilitate fertilization and after a few minutes the eggs were rinsed in fresh sea water to remove the excess sperm, and the frequent changes of fresh sea water were made during the period of incubation of the eggs. The larval stages were treated similarly in the small aquarium until the yolk was absorbed. The number of eggs carried by an adult female varied from about 33,000 to 85,000. In the succeeding days the embryological and prolarval stages were observed under the microscope and recorded, and the series of stages were fixed with 10 percent formalin and preserved in 70 percent alcohol for future study.

Egg

The perivitelline space was not existent in the unfertilized eggs, but in the fertilized eggs the formation of this space was caused by the expansion of the vitelline membrane through absorption of water until the egg reaches its maximum diameter, but the perivitelline space is rather narrow. The diameter of yolk remains uncharged throughout this period.

The fertilized eggs are spherical in form and measure from 1.7 to 1.9 mm. in diameter. The egg membrane is transparent, colorless and thin. There is no pattern of sculpturing on the membrane. The yolk, which entirely filled with the capsule, is slightly pink yellow in life color and transparent. A large oil globule, about 0.4 mm. in diameter, is present with copper-yellow in life color. The specific gravity of eggs is similar to that of sea water so that egg tends to sustend in the middle depth layer of sea water. The eggs and larvae were uncommon in the surface of the open sea, although they were usually found in the middle layer.

Embryonic development

After fertilization the protoplasmic part of egg passes to the animal pole, so appears as a rounded cap, and at about one and a half hour the first cleavage occurs (Fig. A), and the successive development is typical of teleostean eggs. Subsequent cell divisions form blastodermal cap and germ ring at about 10 to 14 hours after fertilization. An embryonic shield next appears at 36 hours and has advanced well beyond the equatorial plane of the yolk. About two days, considerable differentiation has occurred in the embryo, and the notochord, optic vesicles, Kupffer's vesicle and eight to nine myotomes have made their appearance (Fig. B). About three days after fertilization, about 90 myotomes are evident and black pigment appears and Kupffer's vesicle has

almost completely disappeared (Fig. C). Melanophores are distributed irregularly on a large oil globule and found on the head, and appear on the dorsal and anal fin folds. This is a marking characteristic of the egg in appearance. At this stage, the embryo twiches its tail and exhibits wriggling movements of its entire body. The larvae hatched at five to six days after fertilization in the water temperature ranged from 22 to 24 degrees C. By the strenuous thrashing movements of the embryo, the pressure is intermittently exerted upon the egg capsule. The round flap of capsule soon opened and usually larva was observed emerging from the capsule tail first. The empty egg case was deposited to the bottom (Fig. D).

Larval Development

Newly hatched larva (Fig. E)

The newly hatched larvae vary in length from 5.5 to 6.5 mm. and are slender, transparent and pelagic, similar to those of ordinary pelagic larvae. The yolk sac is relatively large and elongate with a large oil globule at posterior end. The vent lies immediately behind the yolk sac, but there is no indication of a mouth or jaws.

The pattern of melanophores is essentially the same as in later stages within the egg and the melanophores of dorsal and ventral fin folds are characterized by fin thread-like ramifications. The dendritic melanophores of the fin folds are concentrated, broadest at the fin margins and thinning out toward the body. The one patch on the dorsal fin fold is centered just posterior to the mid-portion of the body, and the other on the ventral fin fold is slightly behind this. These patches of melanophores are marking characteristic of the cutlass-fish prolarvae so far as observed. In addition, the melanophores appear on the head and oil globule and a series of melanophore extend near the margin of the anterior dorsal fin fold, and a row of melanophores also appears in the lateral line of the body.

During the prolarval stages the larvae remain the head down, floating the middle layer of the jar and when swimming movements occur the body rolls over occasionally.

Prolarva (Fig. F)

At about three days after hatching, the length of larvae has increased to about 7 mm., the yolk sac is much reduced, but an oil globule still remains comparatively large. The head is rather small with the snout pointed, and the mouth and jaws are relatively large and become functional. The preanal part of the body is short, the vent being situated in advance. The pectoral fins have become evident. The vertical fin folds are yet continuous but a few short spines are formed at the anterior part of the dorsal fin fold. The countable number of myotomes is $16 + 90 = 106$.

After the yolk material and oil globule are used up, when the larva remains motionless sinks slowly to the bottom of the jar and occasionally the larva

swims upwards. All rearing larvae were dead on the tenth day.

Postlarva (Fig. G)

At 7.7 mm. long larva, collected on August, off Yushima Island, has changed considerably and pronounced changes occur in the structure of the body and vertical fins. The body is slender and more compressed. The head has become larger and organised. The eyes are larger and the jaws well developed with the granular teeth. The vertical fin folds begin to differentiate. The large three dorsal spines with the spiny barbs on the forward margin, have developed within the anterior part of the dorsal fin fold and also the rays are appearing in the dorsal, anal and pectoral fins. On the other hand, the tip of anal fin has a distinct spine with the spiny barbs on the forward margin. The pectoral fin is rounded and comparatively large.

The melanophores come to disappear, except that on the head and a row along the frontal part of dorsal side. The silvery guanin begins to deposit on the surface of the body.

Juvenile (Fig. H)

At 70 mm. long juvenile, collected on November, off Tomioka, has acquired essentially the form and color of adult fish. The striking characteristic of juvenile is band-like form tapering to a pointed whip-like tail without the caudal fin. The head is relatively small and the mouth is large with a projected lower jaw. Each of the jaws is armed with smaller teeth behind the fangs. The dorsal fin is relatively high and the three dorsal spines have degenerated shorter than the ray behind them, though they are still spinous. The anal fin has reduced gradually to a series of short rays and the fin membrane disappeared, and an anal spine is yet conspicuous. The ventral and caudal fins are not formed throughout the life. The pectoral fins are small and are situated back to the gill covers. The melanophores disappear at all and the body is plain silvery all over. These juveniles occur in the shallow waters and are collected occasionally together with the young of the other fishes.

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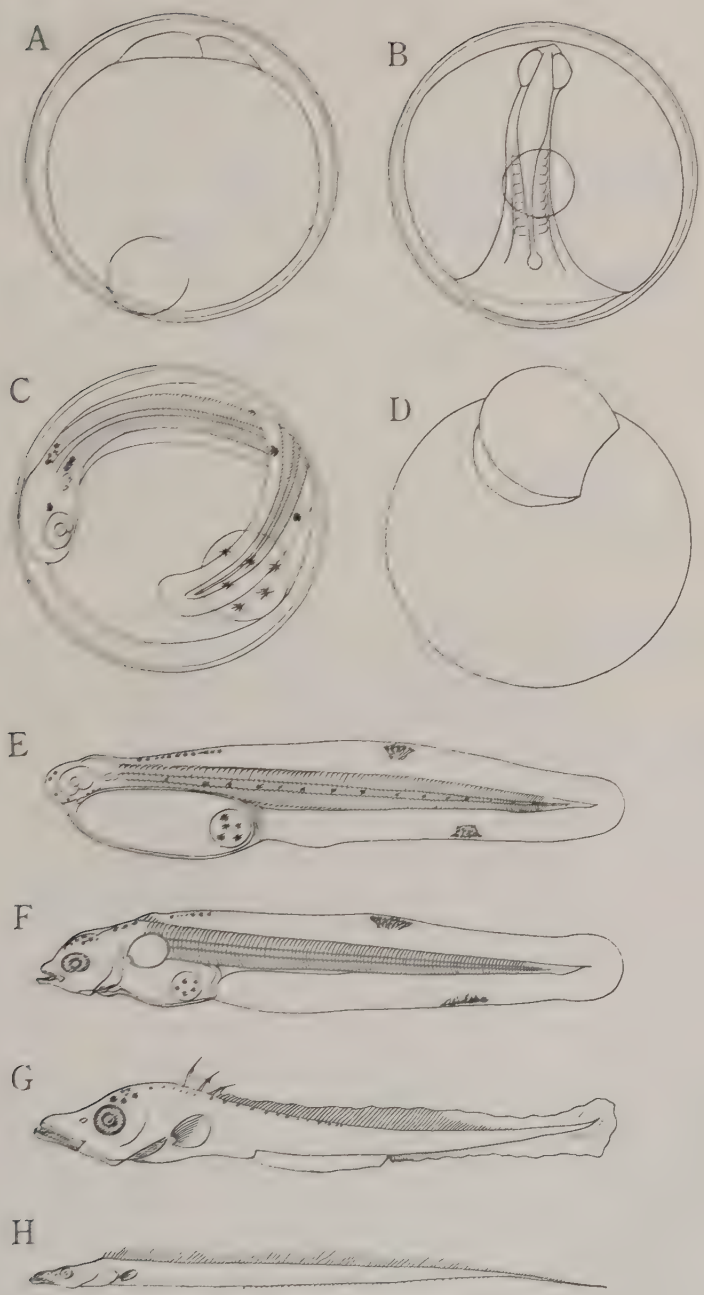

Fig. Eggs and larvae of cutlassfish

A, B, C: Eggs 1.7–1.9 mm. in diameter
D: Egg capsule
E: Newly-hatched larva 6.5 mm. in length
F: Prolarva 7.2 mm. in length
G: Postlarva 7.7 mm. in length
H: Juvenile 70 mm. in length

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STUDIES ON HABITS OF COASTAL FISHES IN THE AMAKUSA ISLANDS

Part I Early Life History of The Purple Rockfish, *Sebastes pachycephalus pachycephalus* Temminck et Schlegel

By

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(* Amakusa Marine Biological Laboratory, Faculty of Science, Kyushu University
** Fisheries Laboratory, Faculty of Agriculture, Kyushu University)

For many years the writers have been engaged in faunal and ecological studies of fishes which are distributed on the coastal waters of Kyushu Province, Japan, especially off the western coast of Amakusa Islands.

The recent years fish fauna and available information relating to the coastal bottom fishes taken by the gill-net have been obtained from these investigation. The work has been carried out in the Amakusa Marine Biological Laboratory, Faculty of Science, Kyushu University. The Amakusa Islands are situated in the warmer temperate region, and the western coast of the outer main island opens to the East China Sea, and the fish fauna are rich.

In present paper we dealt with the early life history of the Rockfish, *Sebastes pachycephalus pachycephalus* Temminck et Schlegel as a part of the results of these investigation. The other information regarding the age, growth and maturity of this species shall be published recently with the information of other fishes. Here we wish to express our thanks to the staff of the Amakusa Marine Biological Laboratory for their assistance in collections, measurements, rearing and others. This species which belongs to *Scorpaenidae* occurs in warm coastal waters in southern Japan and is ovoviviparous. The breeding season was established by a study of maturing ova from month to month and the maturity rate of ovary was the highest in December, while testis in November and namely male matured earlier a month than female. It seemed that the shedding of this larvae from mother fish was most active in January.

Material and Method

The specimens used in this study were caught in the coastal water off Tomioka, Amakusa Islands, by a gill-net and then the mother fishes were reared in the floating fish-preserve and aquarium. When the embryonic development

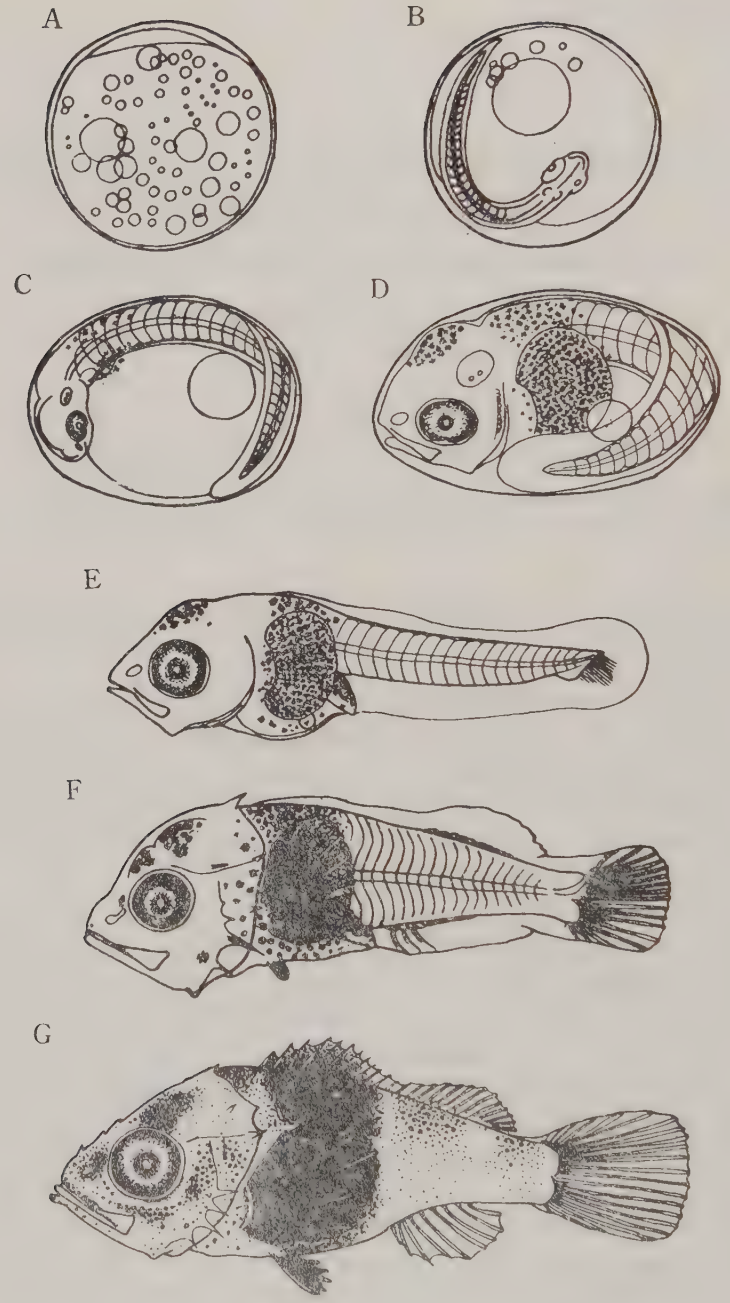

Fig. 1. Eggs and larvae of *Sebastes pachycephalus pachycephalus*
A, B, C, D: Eggs 1.5–1.9 mm. in diameter
E: Prolarva 7 mm. in total length
F: Postlarva 8 mm. in total length
G: Postlarva 13 mm. in total length

was observed, the eggs were pressed out artificially from the belly of matured female. The larvae of them were weak at low temperature in winter, so it is difficult to rear in the open aquarium and the larvae were reared in the small aquarium with thermostat kept about 15°C, fed with the nauplii of brine shrimp.

Egg and Embryonic Development

The eggs are inseminated within the oviduct of mother fish and are spherical in shape with oil globules from 1.5 to 1.9 mm. in diameter, and the egg-membrane thin, the yolk orange yellowish in color, ovarian cavity narrow (Fig. 1, A).

There was no difference compared with the embryonic development of general teleostean eggs. The eggs were transformed into elliptical in shape with progress of the embryonic developments (Fig. 1. C, D). The maturing and mature eggs were the same stages of ovarian development unlike *Sebastes inermis* Cuvier et Valenciennes, which indicated different developmental stages in the same ovary.

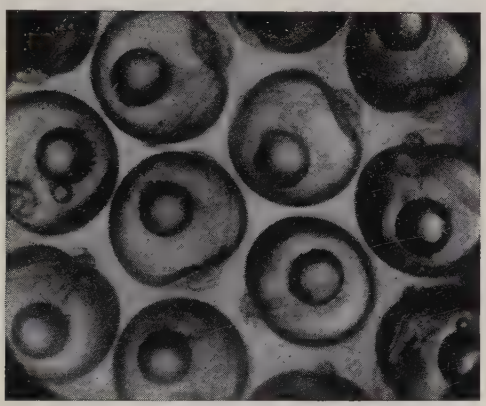

Fig. 2. Eggs in ovary

The female which were collected on January, 12, 1956, had the eggs just after fertilization in the ovary (Fig. 1. A). Rearing this fish, the embryonic development was traced and the results were as follows; on the 1st day after fertilization it became to morula stage, 2nd day gastrula stage, 3rd day formed the embryonal body, the number of myotomes was 20, already formed the optic vesicles and the oil globules of various sizes reduced to a large and several small ones. On the 7th day the oil globules reduced to a single one and the number of myotomes was from 27 to 28, agreeing with the vertebral count of adult, and the embryo started wriggling, and the pectoral fins appeared, and the melanophres appeared on eyes and anterior body (Fig. 1. C). On the 12th day the mouth and gill slit were formed, the melanophores increased on head and anterior body especially on pectoral fins and around it (Fig. 1. D). On the 18th day the larvae hatched out within ovary (Fig. 3). This was a marking

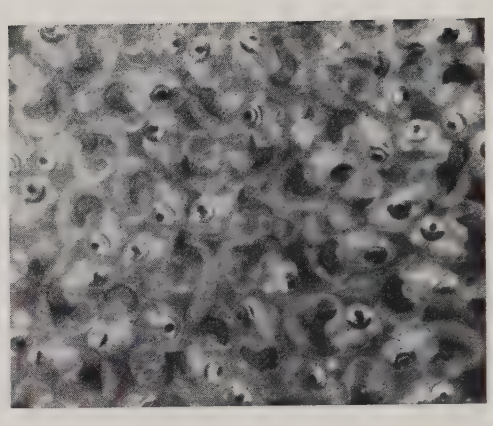

Fig. 3. Larvae in ovary

characteristic of the embryonic development of larvae so far as observed, and at about 20 days after fertilization the larvae began to be shedding out from the female, judging from the observation of the female in fish-preserve, although it may be influenced by sea water temperature.

Larval Development

The newly hatched larvae were from about 6 to 7 mm. in total length and mostly absorbed the light yellowish yolk with a small remnant of oil globule. The mouth was comparatively large and also the pectoral fins enlarged (Fig. 1. E). On the 5th day after their birth they reach about 8 mm. long (Fig. 1. F) and the yolk was completely consumed and they began to fed vigorously on the nauplii of brine shrimp. The pectoral and tail fin rays were clearly observed. The rudiments of the dorsal and anal fins had just appeared in the larval fin fold. The body was orange brown in color and the pectoral fins beared with the minute yellowish in addition to melanophores. The head was large and a pair of large spines with the serrated edge had appeared on the postero-dorsal surface of the head. Four spines had appeared on the posterior rim of the preopercle, a spine on the upper end of it and two spines on the opercle. On the 25th day the larvae attained about 13 mm. long (Fig. 1. G), the black and orange chromatophres were observed on the head and pectoral part. The chromatophres on the pectoral part together with the pectoral fins were almost black and made a darker crossband and two gray cross bands appeared on the posterior body part. The larvae of this stage had drifted in the intermediate water layer but they were ready to sink to the bottomm.

Juvenile

When they attained from about 24 to 25 mm. in length, they were found in the shallow waters above gravely bottom and the body was darker as a whole with four transversal bands on the head, lateral trunk and posterior caudal

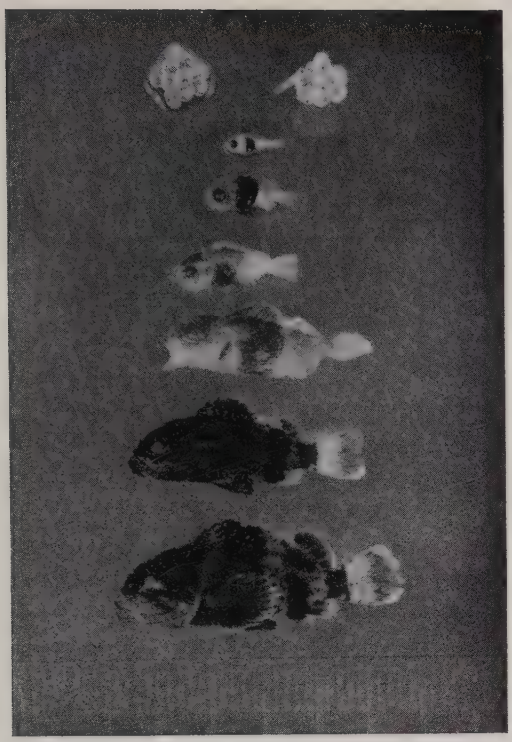

Fig. 4. Eggs, larvae and juveniles
of *Sebastes pachycephalus pachycephalus*

fin (Fig. 4). Until they are from nearly 140 to 150 mm. long the juveniles inhabited in the shallow waters, while the adult had moved into the deeper waters.

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THE BIOLOGY OF THE COMMENSAL COPEPODS IN THE JAPANESE CLAM, *TAPES JAPONICA* DESHAYES

By
Yoshio Kô

A small number of the species of parasitic copepods have been recorded[1)-5)], up to the present, from mollusks of Japan and most of those have heavily degenerated swimming legs. Numerous copepods found in the shells of the commonest Japanese clam, *Tapes japonica,* in February 1959, have, however, well developed swimming legs (like *Myicola ostreae* which was found on the surface of the gills of the Japanese oyster, *Ostrea gigas* THUNBERG, and described by Hoshina and Sugiura[6)]), and can swim swiftly. Besides, these species of copepods seem to live commensalistic with *Tapes japonica,* as is the same case with the pea-crabs[7)].

This paper is the record of the findings on the occurrence and the behavior of these commensal copepods.

I wish to express my sincere thanks to Dr. Otohiko Tanaka of Kyushu University for constant guidance. Thanks are also due to Mr. Kaoru Daiku for much help, to Dr. Yoshie Dotsu of Nagasaki University for valuable advice and encouragement, and to Ass. Professor Seiji Migita of Nagasaki University for technical assistance and material.

Material and Method

The bivalves used were washed immediately in sea water at the place of sampling and again in fresh water after being brought into the laboratory. The specimens of the copepods were collected from the living or fixed samples of bivalves. When a living bivalve was used, after being opened with a knife, the surface of all soft parts of it such as; the gills, the mantles and the other organs, in which the creatures should possibly hide, was cleaned thoroughly in filtrated sea water with the stream of a pipette, then, all the swimming copepods in the water used for washing were collected.

In case of the fixed bivalve, which has been fixed together with shell in the fixing reagents such as ten % solution of formalin, it was treated in the same way as the living clam, however, washed in freshwater instead of sea water, and the adult copepods were mainly collected due to difficulty of finding all the fixed immobile small larvae in the large quantity of water used for the washing.

All used specimens of *Tapes japonica* were longer than 30 mm in shell length.

Results

1. Species

To this date, three species were obtained from *T. japonica* and every one of them belongs to suborder Cyclopoida. Since the taxonomic investigation is now carried on by Dr. O. Tanaka and the description of these species should be soon published by him, I will touch here only on certain characteristics to distinguish them, naming these species temporalily *sp. A*, *sp. B* and *sp. C*.

Sp. A (*Myicola sp.* ?) (Fig. 1, a)

Female, 0.93–1.37 mm long; male, 0.82–1.37 mm long.

The digestive tract is dark green. The second antenna is prehensile with a large claw terminally. The fifth pair of swimming legs is uniramose, 2-segmented and plate-like; the terminal segment is of almost the same length as its width; with three spines on terminal margin. The caudal rami are tapering distally with short setae. Each of two ovisacs contains a row of about five to eleven large eggs. The nauplius immediately after hatching is measured about 0.11 mm long.

On the surface of many adults, there attach numerous Suctoria (about 110 μ long including a stalk) in autumn and winter seasons (Fig. 1, e). The rate of infestation was 21.3% in 366 cases in January 1960 and 46.6% in 319 cases in February 1960 respectively, and some infestation is believed to disturb the swimming movement of the host when it is severe.

Sp. B (*Conchyliurus sp.* ?) (Fig. 1, b)

Female, 1.06–1.64 mm long; male, 0.82–1.53 mm long.

The body is rather elongate. The nauplius eye is pink. The second antenna is prehensile with seven long spines terminally. The fifth pair of swimming legs is uniramose and plate-like; about three times as long as wide; with three spines. The caudal rami are nearly as long as the anal segment; the longest seta is almost three times as long as the caudal rami. Each of two ovisacs contains about 30 to 40 eggs. The nauplius immediately after haching is nearly 0.10 mm long. The infestation by Suctoria happens very rarely.

This species seems to resemble *Conchyliurus cardii* GOODING, which was found in jars containing *Cardium (Acanthocardia) echinatum* LINN. captured near Plymouth and described by R. U. Gooding[8].

Sp. C (*Paraanthessius sp.* ?) (Fig. 1, c)

Female, 1.15–1.77 mm long; male, 0.93–1.31 mm long.

The body is plump. The second antenna is prehensile with three articulated claw terminally. The fifth pair of swimming legs is small with two curved spines, one of which is very long. The caudal rami are longer than the anal segment; the longest seta is nearly twice as long as the caudal rami. Each of two ovisacs contains about one hundred eggs.

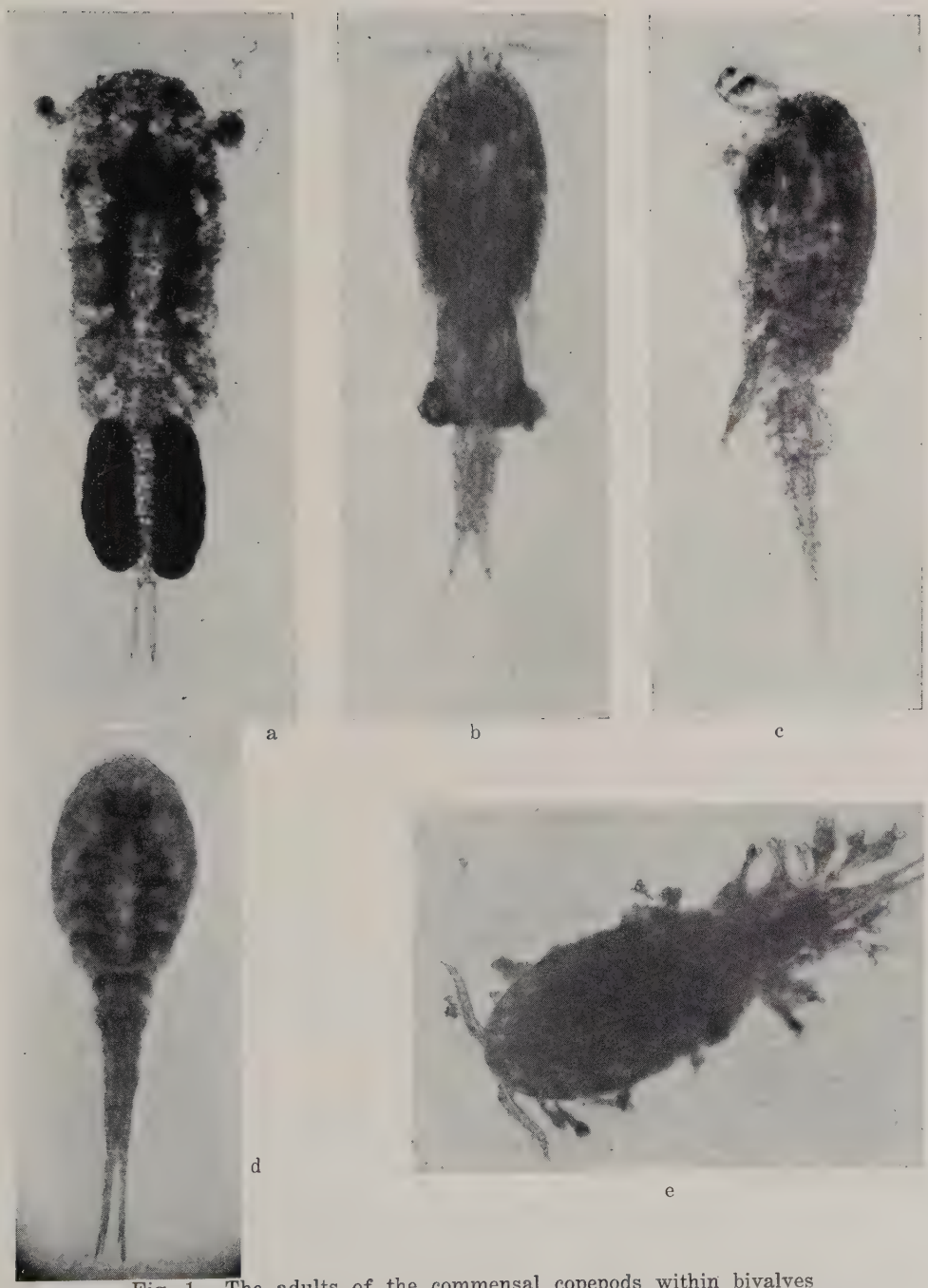

Fig. 1. The adults of the commensal copepods within bivalves
a) female of *sp. A* (*Myicola sp.*?) (1.16 mm in body length) in *Tapes japonica*, b) female of *sp. B* (*Conchyliurus sp.*?) (1.45 mm in body length) in *Soletellina* (*Nuttallia*) *olivacea*, c) male of *sp. C* (*Paraanthessius sp.*?) (1.16 mm in body length, lateral view) in *Tapes japonica*, d) female of *Anthessius sp*? (2.29 mm in body length) in *Pecten* (*Notovola*) *albicans*, e) *sp. A* infested with many Suctoria.

In common to these three species, the swimming legs are developed well as mentioned above, whereas the mouthparts are heavily degenerated. The second antennae with strong claws or spines terminally seem to be strongly prehensile. When the creatures are put in the sea water of a glass vessel, they occasionally scramble up the inner wall of the vessel till one or two centimetres high above the water surface and die from drying up soon. Further, if sucked in a pipette (though it is fairly difficult to suck these copepods in on account of their quick swimming), these creatures often stick themselves so strong to the inner wall of it, that it is fairly difficult to expel them.

Besides the preceeding commensal species, very seldom appears one of free-swimming copepod species, *Microsetella norvegica*. But these copepods are always found dead and it is considered that they have been sucked in after death.

2. Seasonal change in the occurrence of the adults of each copepod species in T. japonica

Although inquiries into the seasonal change of the occurrence could not be done in the year of 1959, remaining samples of *T. j.*, which were used for other purpose several years ago and have been preserved since then, could be utilized. These samples had been collected in the Sasebo Bay at Sakibe-ura once a month from June 1955 to April 1956 period (no sample in November and May), and fixed in Bouin's fluid. The preservation of some extending over a long period of time proved no hindrance to the purpose at this time.

The achieved results are summerized in Table 1.

It is to be noted that from summer to autumn *sp. A* and *sp. B* are dominant and this period nearly corresponds to the main hatching season of both species, while from winter to spring *sp. A* and *sp. C* are abundant and this season also seems to be the main hatching season of *sp. C*. That is, it is seen that, in the Sasebo Bay, within the shells of *T. j.* appears *sp. A* throughout the year, whereas *sp. B* and *sp. C* appear alternately and perhaps chiefly during the main respective hatching seasons. Further, it may be possible that the average number of the occurred copepods for one individual of clam, together with the percentage of infested clams, is large during the main hatching season of *sp. A* and *sp. B* and small during the other season.

In addition, a fair number of male creatures appear in *T. j.*, especially during the breeding season, but the males occur always fewer than the females in every species.

As to the number of copepods found in an individual clam, nineteen was the most (9 females with ovisacs, 6 females without ovisacs and 2 males of *sp. A*; 1 female with ovisacs of *sp. B*; 1 female with ovisacs of *sp. C*) in the clam caught on 17. October, 1955.

3. Local difference in occurrence

The samples of *T. japonica* were collected at the coasts of northern Kyushu from December 1959 to February 1960 period, in order to investigate the local

Table 1. Seasonal change in the number of the adult copepods occurred within *Tapes japonica* in the Sasebo Bay

Species / Sex / Date	sp. A			sp. B			sp. C			Total no. of copepods	Nos. of *T. j.* used	Average no. of copepods for a clam	Nos. of clams infested with copepods	Percentage of infested clams
	♂	♀		♂	♀		♂	♀						
		without ovisacs	with ovisacs		without ovisacs	with ovisacs		without ovisacs	with ovisacs					
June 16, 1955		2	2		2		2	1	1	10	20	0.5	6	30
July 21, 〃	11	4	14	4	11	4		1		49	〃	2.45	19	95
Aug. 16, 〃	2	5	23	7	6	4			1	48	〃	2.4	17	85
Sept. 10, 〃	5	2	17	9	14	13				60	〃	3.0	18	90
Oct. 17, 〃	22	22	42	12	19	4			1	122	〃	6.1	19	95
Dec. 28, 〃	2	38		4	10	3	5	4	8	74	〃	3.7	17	85
Jan. 17, 1956	3	16		2	1		2	5	9	38	〃	1.9	19	95
Feb. 14, 〃		20			1		5	8	5	39	〃	1.95	12	60
Mar. 14, 〃	1	12		1	2		8	13	3	40	〃	2.0	15	75
Apr. 12, 〃		10	1				7	2	5	25	〃	1.25	13	65
Total	46	131	97	39	66	28	29	34	33	505	200		155	
Average												2.53		77.5

Table 2. Local difference in the species and number of the adult copepods occurred in *Tapes japonica*. For a) etc., see Fig. 2.

Date	Locality	Species of occurred copepods	Nos. of occurred copepods	Nos. of *T. j.* used	Average no. of copepods for a clam
Dec. 7, 1959	a) Saga (Ariake Bay)	*sp. A*, *sp. B*	41	20	2.05
Feb. 28, 1960	b) Yue (〃 〃)	*sp. B*, *sp. C*	110	〃	5.5
〃 13, 〃	c) Shimabara (〃 〃)	*sp. B*, *sp. C*	3	〃	0.15
〃 24, 〃	d) Tokitsu (Ômura Bay)	.....	0	〃	0
Jan. 17, 〃	h) Shirahama (Straits of Hirado)	.....	0	40	0
〃 6, 〃	i) Nagoya (Saga Pref.)	*sp. A*, *sp. B*	16	20	0.8
〃 14, 〃	j) Shikanoshima (Hakata Bay)	*sp. B*	4	〃	0.2
〃 〃, 〃	k) Ôtake (〃 〃)	*sp. B*	2	〃	0.1
Feb. 26, 〃	l) Najima (〃 〃)	*sp. B*, *sp. C*	3	〃	0.15
〃 〃, 〃	m) Tsuyazaki (Fukuoka Pref.)	*sp. A*, *sp. B*	6	〃	0.3
〃 12, 〃	n) Moji (Straits of Kammon)	*sp. B*, *sp. C*	7	〃	0.35
〃 6, 〃	o) Ôsaki (City of Toyohashi)	*sp. A*	5	〃	0.25

distribution and the local difference in the occurrence (Table 2 and Fig. 2); this time of the year corresponds to the period, when all three species of copepods appear within *T. j.* in the Sasebo Bay as indicated in Table 1.

Although each of these copepod species seems to distribute all over northern Kyushu, it is likely that there are fairly distinct differences among the samples of *T. j.* gained from various localities with regard to the occurring species and the numbers of the individual of commensals. These local differences may be possibly caused by the difference in the adaptability of each species, in the living density of the bivalves and so on.

The distribution of these copepod species in Japan has not been examined yet, though *Tapes japonica* distributes almost in the entire country.

4. Larvae of the copepods found in Tapes japonica

There are few findings on larvae yet, as the present study is aimed at observation of the adult creatures. There are frequently found a number of nauplii, from about 0.15 mm to 0.18 mm in body length, in the clams. These nauplii are deemed to be the nauplii of *sp. A* and *sp. B*. Many copepodids of every species (from the fifth to third copepodid stage) occur there also. But I have not yet been able to find the copepodids of younger stage.

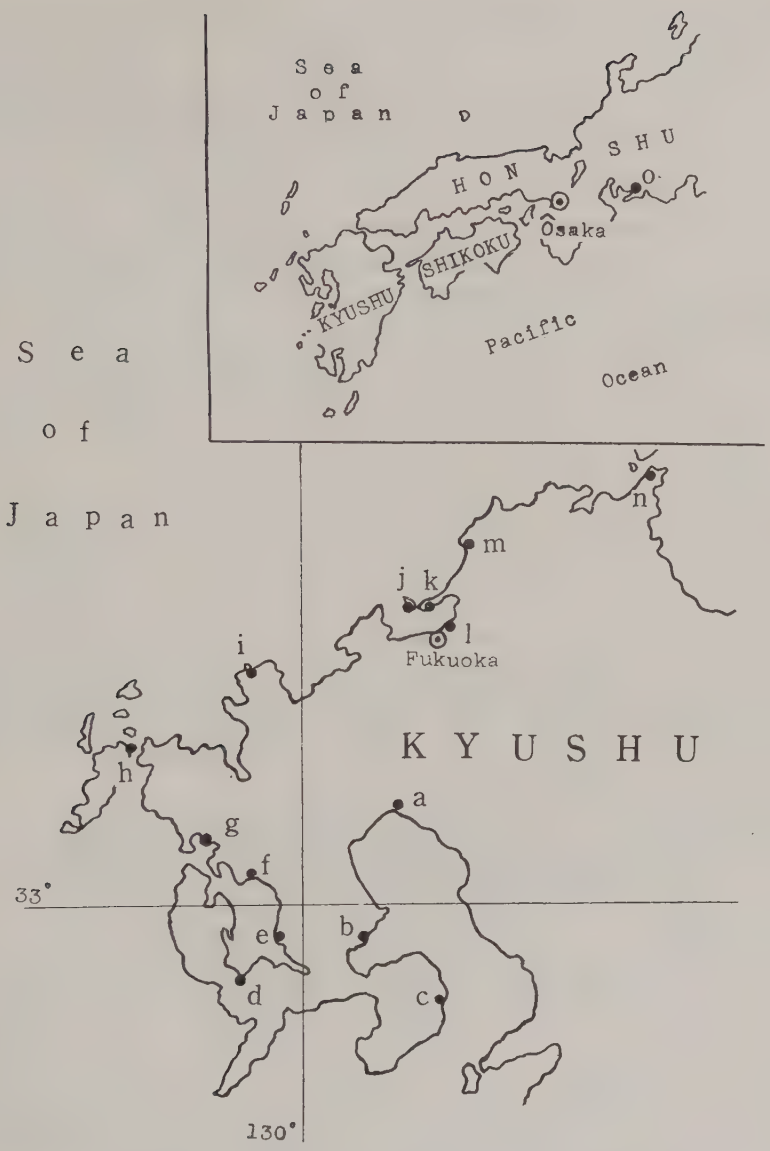

Fig. 2. Sampling localities of bivalves used

a) Saga (Ariake Bay); b) Yue (Ariake Bay); c) Shimabara (Ariake Bay); d) Tokitsu (Ômura Bay); e) Matsubara (Ômura Bay); f) Kawatana (Ômura Bay); g) Sakibe (Sasebo Bay); h) Shirahama (Straits of Hirado); i) Nagoya (Saga Prefecture); j) Shikanoshima (Hakata Bay); k) Ôtake (Hakata Bay); l) Najima (Hakata Bay); m) Tsuyazaki (Fukuoka Prefecture); n) Moji (Straits of Kammon); o) Ôsaki (City of Toyohashi).

5. Observations in laboratory

Position within the host

It is difficult to ascertain accurately the site, where the copepod occupies within a bivalve, because these creatures must move from the initial location as soon as the bivalve is opened or put into some fixing reagent. But very often, when a living bivalve is opened, there are the copepods found in the sea water run out of mantle cavity. They are also frequently found on the surface of gills and in the groove at the base of the inner and outer gills of fixed clams.

Hence it may be roughly said that the creatures exist usually on the surface of various parts such as mantles and gills.

Durability of the copepod in the clam experimentally exposed to the air

The following brief tests were carried out in order to inquire into, whether the copepod could live long in the shut circumstance and the polluted water within a clam.

The washed and wiped specimens of *T. japonica* immediately after being captured were introduced in the empty glass vessel covered with a piece of paper. The samples of clams were taken out one after another from the vessel and then the number of copepods found in each sample was counted.

Table 3 reflects the results obtained. Although the number of occurred copepods immediately after being captured has not been examined, the data on the occurrence of commensal copepods in this period in the Sasebo Bay (Table 1) will serve as a reference. The vitality of *Tapes japonica* itself in the air has been studied by Nakamura[9].

Table 3. The number of the adult copepods in each sample consisting of twenty specimens of *Tapes japonica* experimentally exposed to the air. (l), (d), living and dead copepod

Date of sampling	Time of exposure						Remarks
	1 day	2 days	3 days	4 days	5 days	6 days	
Feb. 13, 1960			22(l) 2(d)		6(l)		
Mar. 2, „	39(l)			26(l)		3(l)	After 4 days, 1 clam, dead After 6 days, 4 clams, dead

On the third and fourth day, the clams appeared to become fairly weak and many of those lolled the siphons long out; neverthless, many individuals of copepods yet remained alive within the hosts.

On the sixth day, in case of March, four clams in the sample of twenty specimens were dead and the rest lost the ability to shut shells, and only three living copepods were found within them. At that time, a large number of individuals of copepods were found dead in such parts of the vessel, as in a little quantity of water spilt out from clams, on the wall or on the bottom.

It may be concluded that these copepods are able to live for a fairly long time under the shut and bad condition in the shells of *Tapes japonica.*

Moving of copepods out of or into living Tapes japonica in water

Following observations were made using twenty specimens of *T. j.* put in a jar containing filtrated sea water of 800 cc.

a. In case of moving out

After 24 hours, the number of copepods in the water and same in all clams in the jar were counted. The results are shown in Table 4.

Table 4. Moving of the adult copepods from the inside of *Tapes japonica* to surrounding water in a jar. Numbers indicate the numbers of adult copepods. Each sample of *T. j.* consists of 20 specimens. * afterwards reckoned

	At beginning		After 24 hours	
	In water	In *T. j.*	In water	In *T. j.*
Test I	0	46*	10	36
Test II	0	29*	8	21
Test III	0	41*	10	31

b. In case of moving into

A number of copepods collected from the other sample of *T. j.* after computation were put into the jar. After 17 or 48 hours, the number of copepods in the water and in the shells was counted. The results are shown in Table 5.

Table 5. Moving of the adult copepods (collected from the other sample of *Tapes japonica*) to the inside of T. j. from the water surrounding it in a jar. Numbers indicate the numbers of adult copepods. Each sample of *T. j.* consists of 20 specimens. * afterwards reckoned

	At beginning		After 17 hours		After 48 hours	
	In water	In *T. j.*	In water	In *T. j.*	In water	In *T. j.*
Test I	51	29*	7	73		
Test II	48	32*			21	59

Since these tests were carried out under the conditions which differed extremely from the natural conditions, it is doubtful, whether or not the moving of so many individuals happens actually in the sea. However, the results obtained from these tests may perhaps mean that it is possible for these adult copepods to move in and out of living bivalves in the sea without experiencing much difficulty.

Behavior

In the course of the tests described above, following observations have been made on the behavior of the copepods in the jar.

When the creature collected from the other sample of clams is set free into the water, it often shows a tendency to move along with the stream made by

a clam without swimming; however, it comes frequently out of the stream by a sudden swim. Therefore, it is deemed possible that the copepod resists against the water stream created by the clam and escapes from it.

Thus, after being released, some individuals soon move along with the stream without swimming into the clams through inhalent siphons, while other individuals which are majority in numbers move downwards either by means of being carried along with the stream or swimming until they arrive at the proper localities to rest such as on the outside of shells or siphons, among the tentacles of the siphons or on the bottom of the vessel. In this case, they usually remain almost quiescent for a fairly long time at the sites where they have fallen, changing occasionally, perhaps by creeping, the sites only a very little. It happens also now and then that these resting individuals suddenly swim up but immediately go down in the manners mentioned above, however, none ever swim about or creep about.

As under mentioned, there were found numerous individuals of *sp. B* within the little bivalve, *Soletellina (Nuttallia) olivacea* (JAY), which lives buried in sand at tidal zone as *T. japonica*. When these bivalves were kept alive in the filtrated sea water renewed every few days within a beaker without any sand or food being given, the copepods could live for about three months from January to March. During this keeping period, it was frequently observed that the copepods went in and out through the aperture between the mantles of bivalves.

6. Occurrence of the copepods in other bivalves

The examined species of bivalves are very few as yet (Table 6). The bivalves, in which any of these three copepod species were found, are *Meretrix lusoria* (RÖDING), *Mactra sulcataria* REEVE and *Soletellina (Nuttallia) olivacea* (JAY), and further, one more similar species larger in size (Anthessius sp. ?)

Table 6. Copepods found in other bivalves. For d) etc., see Fig. 2.

Date	Locality	Species of bivalves	Species of copepods	Nos. of copepods	Nos. of bivalves examined
Jan. 24, 1960	f) Kawatana (Ômura Bay)	*Protothaca (Protothaca) jedoensis*	*Microsetella norvegica*	14	10
〃 〃 〃	〃 (〃)	*Gafrarium divaricatum*	〃	1	20
Feb. 24, 〃	d) Tokitsu(〃)	〃 〃	.....	0	14
〃 28, 〃	g) Sakibe (Sasebo Bay)	〃 〃	.....	0	20
〃 8, 〃	e) Matsubara (Ômura Bay)	*Mactra sulcataria*	*sp. C*	2	20
Jan. 14, 〃	k) Ôtake (Hakata Bay)	*Soletellina (Nuttallia) olivacea*	*sp. B*	25	20
Mar. 4, 〃	(Ariake Bay)	*Meretrix lusoria*	*sp. A*, *sp. B*	4	20
〃 〃 〃	near Sasebo	*Pecten (Notovola) albicans*	*Anthessius sp. ?*	5	2

(Fig. 1, d) was obtained from *Pecten (Notovola) albicans* (SCHRÖTER). It is remarkable that there were no copepods in *Gafrarium divaricatum* (GMELIN), which was collected in the Sasebo Bay from the same ground where *Tapes japonica* inhabits.

Discussion

It is obvious from the external morphology and the behavior that these copepod species have a considerable moving ability. It is, therefore, considered that these creatures never live parasitically, attaching to body parts of bivalves, but have a more active way of living. Accordingly, the constant existence of so many individuals of copepods inside the bivalves must result from, either residing there associated with the life of the bivalves or remaining there in consequence of being sucked in by chance and prevented from going out of shells, in spite of living usually freely in the sea.

Although their external morphology seems to suggest the former case that these creatures live within bivalves, none of such definite evidence was gained by the investigations at this time to prove this directly, as the finding that they actually utilize the interior of the shells of bivalves for some purposes such as feeding, reproduction, shelters and so on. However if it is possible to prove that the occurrence of many copepods in bivalves is due to their active movement, and not to their being sucked passively and to their impossibility of escaping from there, then, it may probably be said that these creatures utilize the bivalves as a place of life.

It seems to be relatively easy to decide between the two alternatives of moving actively or passively from the certain characteristics of their behavior mentioned previously. Since the abilities to swim quickly, to resist the stream made by bivalves, to attach themselves to anything, to creep and so on, are considered as an indication that these copepods can keep out of being passively sucked in and escape freely from shells (on the occasion of moving in and out of shells). That is, when the creatures get in the stream of bivalves for inhalation, it is deemed not difficult to escape from it by swimming or attaching themselves to something, not only at the laboratory tests mentioned above but also in the sea. Further, if the copepods had been accidentally sucked into shells, they should be able to go out by means of moving along with water stream for exhalation, or creeping through siphons or the aperture between mantles. Accordingly, it may be inferable with more certainty that the constant existence of these copepod species inside the bivalves is due to their active actions, but not to their passive moving and for this reason, they are the commensals of the bivalves, and not the temporary prisoners. Then, it is easily understood that various observed peculiarities in the structure, the ability of attaching, the habit of moving along with stream, the duarability in the shells exposed in the air and others seem to be adapted to the life inside the bivalves.

These copepods may often change their hosts, unlike the pea-crabs. Further investigations of the more important subjects as the nature of the commensalism are believed to be necessary.

As previously mentioned, there are local differences between the samples of *Tapes japonica* with regard to commensal copepods and these differences appear to be fairly great in both the occurring species of the copepods and the number of the occurring individuals of each copepod species. In the future, if it is possible to clarify the cause of these local differences and the relationship between the environment of *T. j.* and that of each copepod species, it will help to elucidate and infer indirectly the suitable conditions for inhabitation of *T. j.*

Summary

A study has been made of the occurrence of the copepods, belonging to suborder Cyclopoida, within the common Japanese clam, *Tapes japonica* DESHAYES, and the behavior in the laboratory.

Three species of these copepods, though as yet unidentified, are found in *T. j.*. Through the year, in the Sasebo Bay, the number of the occurred copepods for an individual bivalve averages about 2.5 and the percentage of infested clam averages nearly 80. One of the three species *(sp. A)* is dominant all the year round in *T. j.* of the Sasebo Bay, while the other two species *(sp. B* and *sp. C)* appear alternately in a large number during the respective main breeding seasons. A fair number of male individuals are found in the clam, but always the males are fewer than the females. There are fairly distinct differences among samples of the bivalve collected from various localities (in northern Kyushu) with regard to the occurring species and the number of the individuals of the copepods.

The body length of these copepods ranges from 0.9 mm to 1.8 mm and every species has developed swimming legs, prehensile second antennae with terminal strong claws or spines and degenerated mouthparts. Furthermore, it can swim swiftly, attach itself tightly to anything, resist the water current made of the bivalve, creep forwards and endure the bad condition in the water inside the bivalve exposed long to the air. These peculiar features on structure and behavior seem to indicate that these copepods dwell commensalistic with *Tapes japonica.* A number of nauplii and copepodids (from the third to fifth stage) were found within the clams.

These species occur also in certain other bivalves as *Meretrix lusoria* (RÖDING) and one more similar species was found in *Pecten (Notovola) albicans* (SCHRÖTER).

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in Japan (Special Number 5)
March 1961

ON THE MATURITY OF WHITE CROAKER, *ARGYROSOMUS ARGENTATUS* (HOUTTUYN)

By

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For reasonable utilization of marine resource, it is more important, though difficult, to estimate the reproduction of organism in the various biological characters among research problems. In order to get the fundamental knowledge to understand the reproductive potence, the author estimated fecundity of an important bottom fish, white croaker, *Argyrosomus Argentatus* (HOUTTUYN). From the observation of maturing process of ovaries, the spawning period and behavior were investigated by measuring the egg-diameter distribution and histological method.

It is a pleasure to acknowledge here the advice and assistance rendered by a number of persons during the course of this work. The author especially indebted to Dr. Hiroaki Aikawa and Dr. Hiroshi Tsukahara of Kyushu University for their guidance throughout this investigation and the writing of this paper.

Material and Method

About one hundred specimens were used in this study. The ovaries were removed from these specimens and were fixd with 10 percent formalin fluid. The number of intra-ovarian eggs was calculated by Hensen's method and histological sections were made by celloidin method. The ovaries were weighed respectively and the inspection was made on the egg-diameter distribution. Since there was no difference in the distribution at each part, a piece of 1 gr. at middle part of ovary was used in calculation afterwards. The sample piece was untied and stirred to be uniform in a glass of 100 cc water and the eggs were sucked up with water by Stempel pipette of 0.5 cc. The eggs from each sample were spread on a glass-slide marked with vertical parallel lines and were counted under a microscope ($\times 50$) with an ocular micrometer. Histological sections of ovaries which were the same part were from 15 to 25 μ in thickness. After double staining of them with Haematoxylin-Eosin, the author observed the histological characters with the same microscope.

Observation of Ovaries

The monthly changes of gonad index (ovary weight/body weight$\times 10^3$) of white croaker were investigated and the value of gonad index increase rapidly

from May, the period of its maximum value was found in July, and decreased in value from August on. (Fig. 1). The spawning season, thus, is seemed to be in these four months from May to August and the occurence of spawning peak in July can be shown by this investigation. The observation of ovaries were taken thrice a month by about ten individuals at a time.

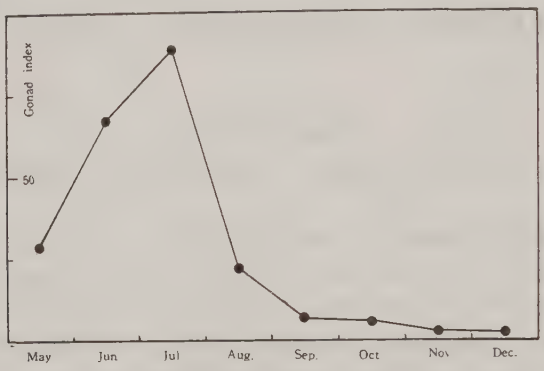


Fig. 1. Monthly change of gonad index

From the egg-diameter distribution there are three distinguished types of ovaries: O type has no mode; I type has one and II type has two modes. The ovary of O type consists of the immature eggs in which no distinct mode is present. The ovary of I type consists of the developing eggs in which one distinct mode is present at an average egg-diameter of 0.4 mm. The ovary of II type comprises with two masses consisting of the developing eggs and of matured, the former is present at an average diameter of 0.4 mm and the latter at 0.7 or 0.8 mm. (Fig. 2).

On the histological inspection of the described egg-diameter distribution, eggs of 0.1, 0.4, 0.7 and 0.8 mm at an average diameter are respectively consisted of eggs named cytologically, i.e., of the later peripheral nucleolus stage (stage I), of the later yolk globule stage (stage II), and of the pre-maturation stage and the ripe egg stage (stage VI and VII) (Fig. 3). The follicle cells rounding the ovarian eggs have been known to the investigators that they are gradually absorbed in the ovarian tissue after ovulation. Depending on whether follicle cells are new or old, and present or not, it can be shown how many times it has passed after ovulation and whether the fish spawned or not. In later spawning period the egg mass of stage IV begins to contain a number of decaying eggs which can not develop to the functional eggs. In the histological viewpoint there are five types of ovary: A type has no follicle cells; B type has only new; C type has new and old; D type has only old and E type has decaying eggs (Plate I).

Thus, in the combination of the results of histological assortment with the results of egg-diameter distribution, the writer distinguished the ovaries respectively into the following types, i. e., A-O type, A-I type, A-II type, B-O

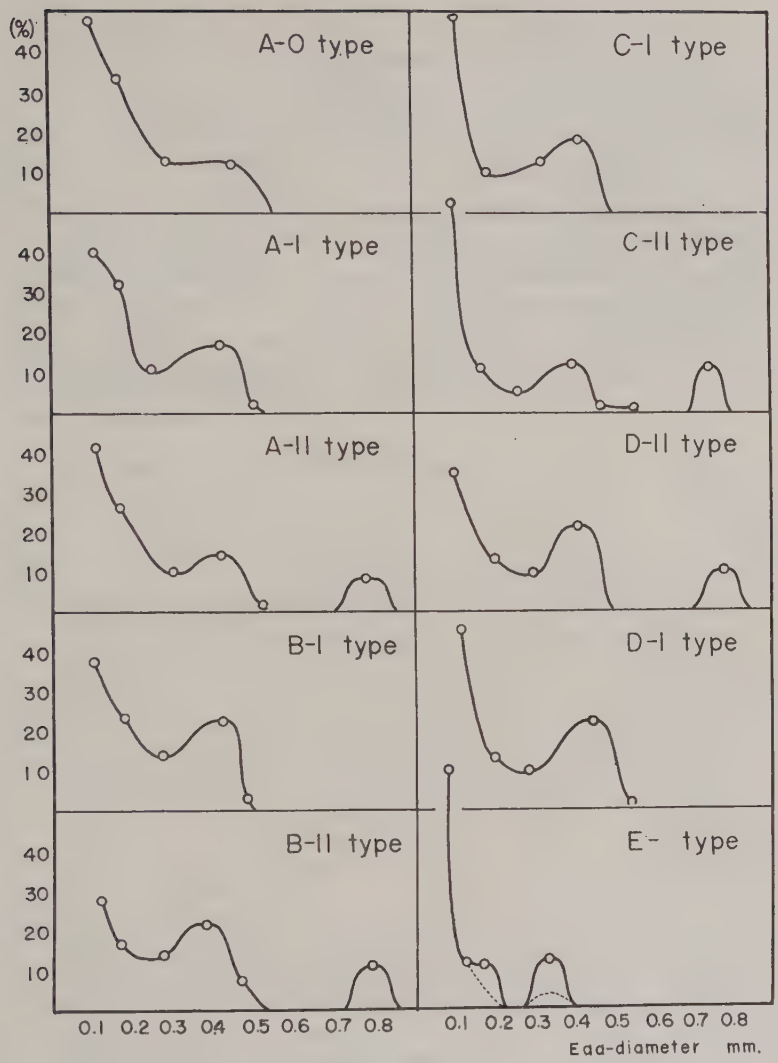


Fig. 2. Diameter distribution of ovarian eggs

type, ..., D-II type. The ovaries from A type to D type have all ripe egg mass and it was only A type that had no mode. Corresponding to the passing of spawning period, the types of ovaries are changing from A type to E type. It is not likely that the repetitions from B type to D type are done in a spawning season, though the assortment of these types still remains in further works. The follicle cells, in this study, remain in the tissue about two weeks after ovulation. Since a number of ovaries of C type were found in a spawning season, it is considered that the follicle cells would stay to the next spawning time. Thus the spawning times were estimated about three times or four. Immediately after it should have been ovulated, the ripe eggs were often observed

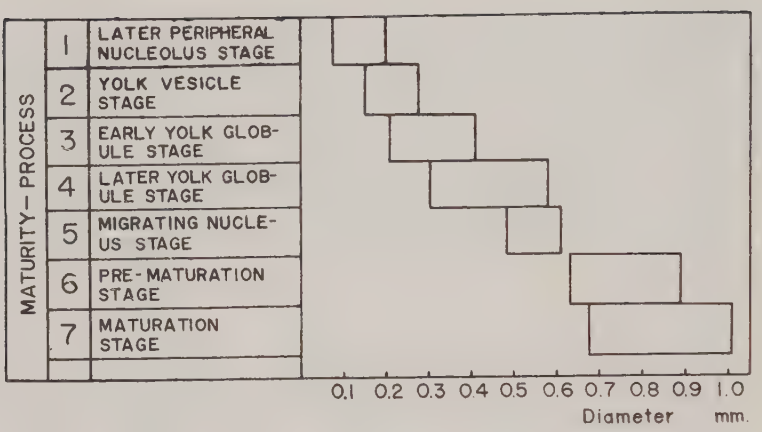

MATURITY—PROCESS
1 LATER PERIPHERAL NUCLEOLUS STAGE
2 YOLK VESICLE STAGE
3 EARLY YOLK GLOBULE STAGE
4 LATER YOLK GLOBULE STAGE
5 MIGRATING NUCLEUS STAGE
6 PRE-MATURATION STAGE
7 MATURATION STAGE
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Diameter mm.

Fig. 3. Diagram showing maturity-process of ovarian eggs

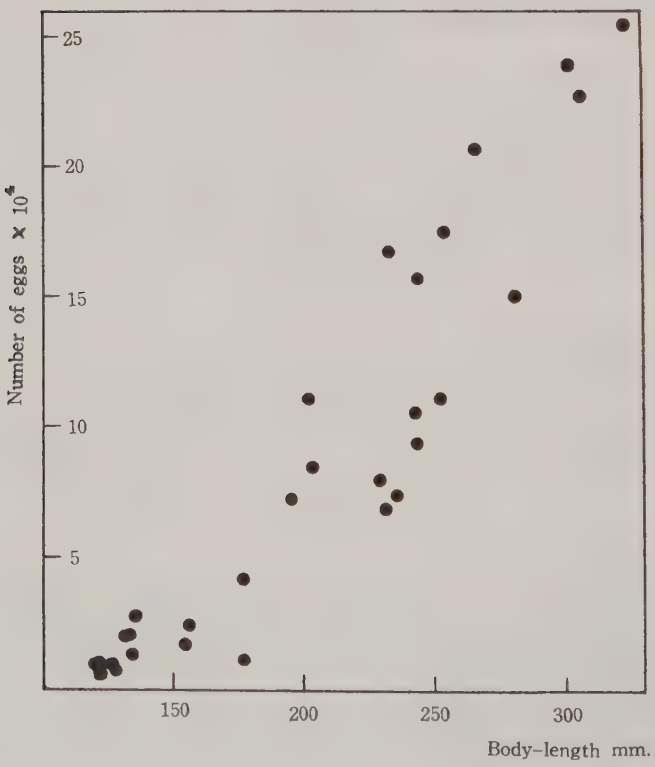
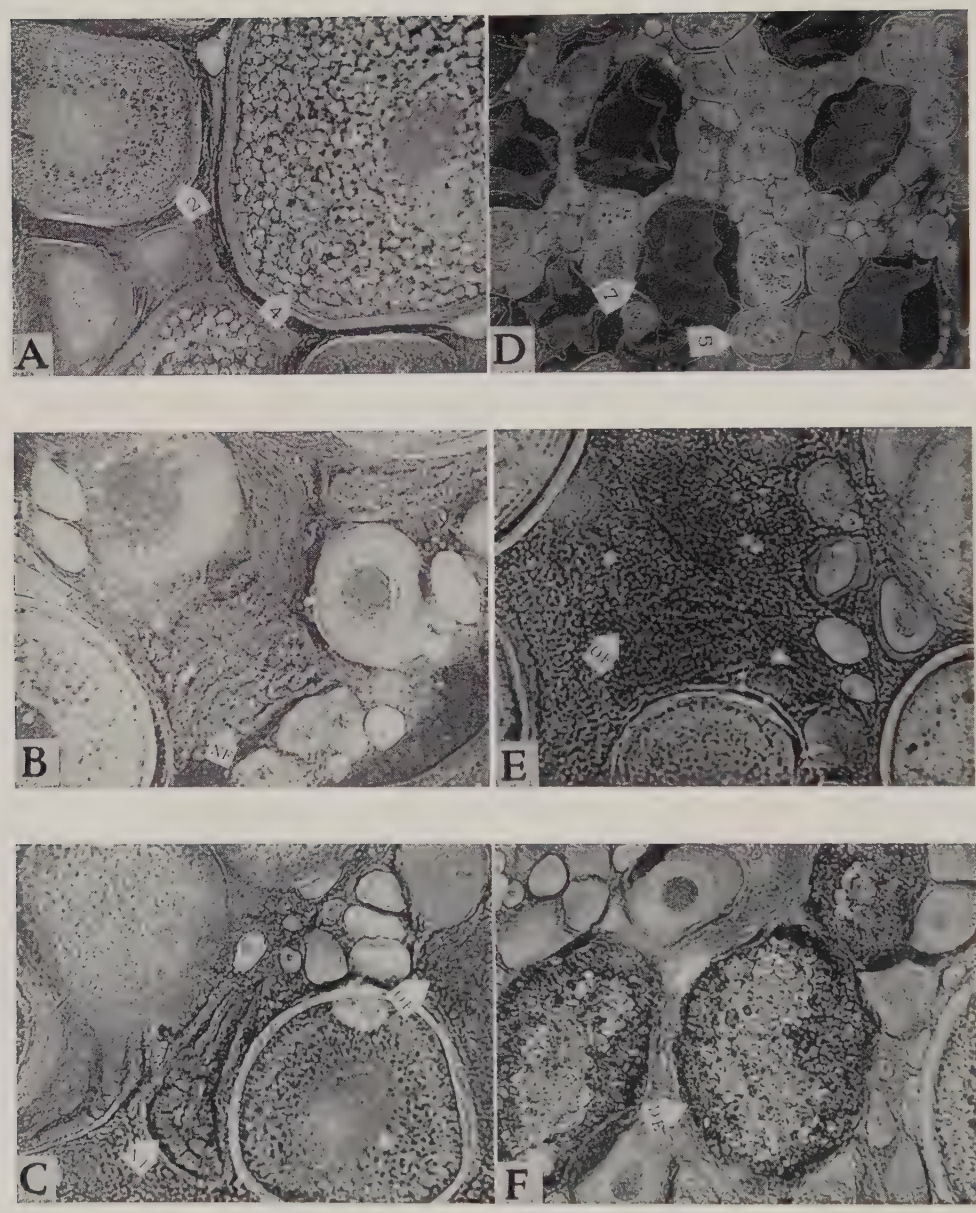


Fig. 4. Relationship between body length and number of eggs in the most matured batch

in the ovarian cavity and not entirely in the ovarian tissue. As the egg mass of stage IV is already recognized at that time, these eggs will not recruit into a ripe egg mass. Therefore a ripe egg mass separating egg-diameter from other mass was estimated to be the fecundity and was counted in each age individual.

Thus, spawning season of white croaker was in these four months, from the latter part of May to the first part of August and the peak of spawning was in July. The spawning frequencies of individuals were three times or four in a spawning period and the total egg numbers of one spawning behavior in each age of one, two, there and four were respectively 13,000, 64,000, 115,000 and 219,000 as average (Fig. 4).

PLATE 1



A: ovary of A type (×230)
B: ovary of B type (×230)
C: ovary of C type (×230)
D: ovary of C–II type (×50)
E: ovary of D type (×230)
F: ovary of E type (×230)

2: yolk vesicle stage
4: yolk globule stage
5: migrating nucleus stage
7: ripe egg
N. F.: new follicle cell
O. F.: old follicle cell
D. E.: decaying egg

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ON THE EARLY LIFE HISTORIES OF THE BATHYPELAGIC FISHES OBTAINED IN THE SOUTHWESTERN SEA OF KYUSHU
(Preliminary Report)

By

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(Faculty of Fisheries, Kagoshima University)

In the last five years, the author has examined a large number of fish-larva obtained by the research vessels of Kagoshima University and Kagoshima Prefectural Fisheries Experimental Station in the southwestern sea of Kyushu, where the eastern East China Sea slopes down to the great depth of Ryukyu Trench, and has found numerous larva and juvenile of the bathypelagic fishes among them. Although the specimens were generally quite young, due to the fact that the collections were mainly made by the surface tows of larval nets, they seemed to be sufficient to show clearly the early histories of their lives.

The species hitherto identified are listed below. All specimens are deposited in the author's labolatory and now under investigation.

Gonostomatidae
1. *Diplophos orientalis* (MATSUBARA)
2. *Gonostoma gracile* (GÜNTHER)
3. *Cyclothone sp.*
4. *Yarrella sp.*
5. *Maurolicus japonicus* ISHIKAWA
6. *Vinciguerria lucetia* (GARMAN)

Sternoptychidae
7. *Sternoptyx diaphana* HERMANN

Chauliodontidae
8. *Chauliodus sloani* SCHNEIDER?

Stomiatidae
9. *Stomias sp.*

Astronesthidae
10. *Astronesthes sp.*

Idiacanthidae
11. *Idiacanthus panamensis* REGAN et TREWAVAS

Melanostomiatidae
12. *Melanostomias sp.* A
13. *Melanostomias sp.* B
14. *Leptostomias multifilis* IMAI
15. *Photonectes albipinnes* (DÖDERLEIN)

Evermannellidae
16. *Evermannella indica* BRAUER

Myctophidae

17. *Hygophum reinhardti* (LÜTKEN)
18. *Benthosema suborbitale* (GILBERT)
19. *Diogenichthys laternatus* (GARMAN)
20. *Myctophum californiense* (EIGENMANN et EIGENMANN)
21. *Myctophum evermanni* (GILBERT)
22. *Myctophum affine* (LÜTKEN)
23. *Myctophum spinosum* (STEINDACHNER)
24. *Myctophum asperum* RICHARDSON
25. *Myctophum orientale* GILBERT
26. *Diaphus agassizi* GILBERT
27. *Diaphus nipponensis* GILBERT
28. *Notolychnus valdiviae* (BRAUER)
29. *Lampanyctus microchir* GILBERT
30. *Lamanyctus niger* GÜNTHER
31. *Lampanyctus macropterus* (BRAUER)
32. *Lampanyctus punctatissimus* GILBERT
33. *Lampanyctus ritteri* GILBERT
34. *Ceratoscopelus townsendi* (EIGENMANN et EIGENMANN)
35. *Centrobranchus nigro-ocellatus* (GÜNTHER)

Chiasmodontidae

36. *Pseudoscopelus scriptus* LÜTKEN

Bregmacerotidae

37. *Bregmaceros japonica* TANAKA

Ceratiidae

38. *Ceratias sp.* ?

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STUDIES ON THE YOUNG OF MARINE ANIMALS CAUGHT WITH "SHIRASUFUNABIKIAMI", A BOAT-SEINE OF MINNOW NET, OPERATING IN COASTAL ZONES OF THE WESTERN JAPAN Part I

Larvae and Young of Gobioid Fishes

By

Yosie Dôtu

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In the coastal zones of the Western Japan, various kinds of "Shirasufunabikiami", a boat-seine of minnow net, operated to catch the shoals of young fishes of anchovy *Engraulis japonicus*, sardine *Sardinops melanosticta*, round herring *Etrumeus microps* and sand eel *Ammodytes personatus*. They operate in the coastal zones of sandy or sandy mud bottom at the depth of 5 to 30 metres, and mainly from spring to autumn. They have a bunt of minnow net, and catch the larvae and young of various kind of marine animals together with above mentioned young fishes (Text-Fig. 1).

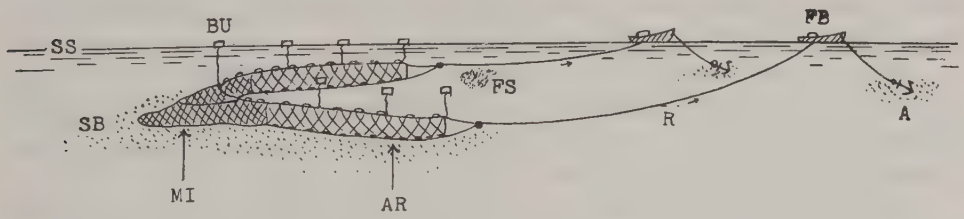

Fig. 1. Operating "Shirasufunabikiami", a boat-seine of two boats type SS sea level; SB sandy bottom; MI bunt of minnow net; AR arm of large mesh net; BU buoy of the net; R rope, towing the net; FB fishing boat with a rope hauller; A anchor; FS a shoal of swimming young fish of anchovy.

The author has collected the specimens caught with "Shirasufunabikiami" from 10 localities of the Western Japan shown in Text-Fig. 2. He has studied on the specimens for several years in oder to find newly the fries of animals for aquarium, those for aqui-culture and those for bait and forage in them. The larvae and young of gobioid fishes, belonging to 11 genera and 15 species, have been detected on the specimens as shown in Table 1.

From the examination of fishing characteristics of "Shirasufunabikiami" and the specimen of one haul catch of the net, the larvae and young of the

Fig. 2. Localities of the Western Japan where the specimen of "Shirasu-funabikiami"-catches was collected.

A coastal zone of Susaki City, Kochi Pref.; B coastal zone of Hamada City, Shimane Pref.; C Uya Bay, Yamaguchi Pref.; D Hamakusu Bay, Tsushima Isls., Nagasaki Pref.; E Fukuoka Bay, Fukuoka City, Fukuoka Pref.; F coastal zone of Matsuura City, Nagasaki Pref.; G Nama Bay, Gotō Isls., Nagasaki Pref.; H Aokata Bay, Gotō Isls., Nagasaki Pref.; I coastal zone of Tomioka, Amakusa Isls., Kumamoto Pref.; J Shibushi Bay, Kagoshima Pref.

gobioid fishes seemed to live a swimming life individually or gregariously in the middle and bottom strata of coastal waters.

The larvae and yong of *Astrabe lactisella* and *Luciogobius guttatus*[2] seemed to live an individual swimming-life, and those of *Pterogobius virgo*[1], *Pterogobius zacalles*[1], *Chaeturichthys hexanema*[3] and *Leucopsarion petersi*[4] seemed to live a gregarious swimming-life. They fed on pelagic copepods.

The origins of the larvae and young of the gobioid fishes are various. *Rhinogobius similis*[5] and *Chaenogobius urotaenia*[6] live an individual bottom-life in the middle and lower parts of river and spawn there. *Acanthogobius flavimanus*[7], *Chaenogobius castanea*[8], *Pleatogobius uchidai*[9] and *Luciogobius guttatus*[2] live an individual bottom-life in the littoral and shallow zones of bay and spawn there. *Chaenogobius heptachanthus*[10] live a gregarious swimming-life in the shallow zone of bay. *Pterogobius virgo, Pterogobius zacalles, Chaerturichthys hexanema*[3] and *Heteroplopomus barbatus* live an individual bottom-life or swimming-life in coastal zones. *Astrabe lactisella* live an individual bottom-life in the tide pool on rocky shore. *Leucopsarion petersi*[4] live a gregarious swimming-life in the bay and come to estuary to spawn its eggs in spring.

Pterogobius virgo[11], some 200 mm in total length, is brilliant in color and *Pterogobius zacalles*[11], some 100 mm, is delicate. They are both tough, and

Table 1. Larvae and young of gobioid fishes caught with "Shirasufunabikiami", a boat seine of minnow net, operated in coastal zones of the Western Japan

Species No.	Specific name	Japanese name	Range of total length in mm	Catching season	Locality *
1	*Rhinogobius similis* (GILL)	Yoshinobori	10~15	May to June	A
2	*Acanthogobius flavimanus* TEMMINCK et SCHLEGEL	Mahaze	12~20	March to May	E
3	*Pterogobius virgo* TEMMINCK et SCHLEGEL	Nishikihaze	30~60	February to April	H
4	*Pterogobius zacalles* JORDAN et SNYDER	Ryūgūhaze	41~58	April to May	H
5	*Chaenogobius urotaenia* (HILGENDORF)	Ukigori	9~26	March to June	B, E
6	*Chaenogobius castanea* (O'SHAUGHNESSY)	Biringo	10~15	February to April	B, E, J
7	*Chaenogobius heptacanthus* (HILGENDORF)	Nikuhaze	10~30	April to June	E
8	*Paleatogobius uchidai* TAKAGI	Chikuzenhaze	10~15	March to May	E
9	*Chaeturichthys hexanema* BLEEKER	Akahaze	10~26	April to May	C, E
10	*Chaeturichtys sciistius* JORDAN et SNYDER	Komochijako	17~30	May to July	A, G, H, I
11	*Sagamia genionema* (HILGENDORF)	Sabihaze	15~60†	March to June	B, F, G, H
12	*Heteroployomus barbatus* (TOMIYAMA)	Niramihaze	7~11	September to December	A
13	*Astrabe lactisella* JORDAN et SNYDER	Shirokurahaze	7~12	February to May	A
14	*Leucopsarion petersi* HILGENDORF	Shirouo	29~41††	December to January	A, C, G
15	*Luciogobius guttatus* GILL	Mimizuhaze	7~22	October to May	A, G, H, J

* Localities shown in Text-figure 2
† Including immature fish
†† Immature fish

rapidly grow and live a swimming-life in an aquarium. They are valuable as marine aquarium fish. It is difficult to catch numerously the adult of the gobioid fishes, but the young of the fishes had been caught rather numerously with a "Shirasufunabikiami" in Aokata Bay, Gotō Isls. from February to April (Table 1).

The author wishes to express his gratitude to Dr. K. Uchida for his kind guidance in this research.

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STUDIES ON THE PELAGIC FISH EGGS AND HATCHED LARVAE FOUND IN THE ADJACENT WATERS OF JAPAN

By

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Many marine fishes beget pelagic eggs and are rather easily caught by a tow net, but many of them still remain unidentifiable.

The author has been engaged in the classification of these eggs and hatched larvae in order to make the keys of them.

To classify the pelagic eggs and hatched larvae, the author used following characteristics.

Egg Size and Shape

Most of the pelagic eggs are spherical in shape, but some of them are ellipsoidal or in other shapes (Pl. 2, No. 1). The diameter of the pelagic eggs ranges from 0.5 to 4.8 mm, mostly 0.8 to 1.5 mm.

Egg Membrane

Usually colorless, thin, transparent and without any conspicuous structure, but some species belonging to the suborders Clupeina, Stomiatina, Myctophina, Exocoetina, Uranoscopina, Pleuronectina and Soleina have hexagonal mesh structure (Pl. 1, No. 14), gelatinous coats or some appendages (Pl. 2, No. 5) on their egg membrane. The egg membrane of clupeid and apodal fishes sometimes glisten, and in box fishes it is something thick and semitransparent.

Perivitelline Space

Usually narrow, but in some species belonging to Clupeina, Stomiatina and Pleuronectina are considerably wide, in Anguillina usually wide (Pl. 1, No. 9, Pl. 2, No. 14).

Yolk

Mostly colorless and homogeneous, but many species have segmented yolk, especially in Clupeina, Anguillina, Carangina etc. (Pl. 1, Nos. 7 and 9, Pl. 2, Nos. 1 and 14).

Oil Globule

The pelagic eggs can be divided into three groups according to the absence (Pl. 1, No. 2: Pl. 2, Nos. 1, 13 and 14) or presence of a single oil globule (Pl. 1, Nos. 5, 7 and 9, Pl. 2, Nos. 3, 7 and 8) or oil globules (Pl. 1, Nos. 11 and 14). In some cases a single oil globule separates into 2 to 5 globules, or several oil globules unites into one during the course of the egg development (Pl. 2, No. 5). Size, coloration and position in the yolk and the number of oil globules vary according to the species or in the course of the egg development.

Pigmentation

Sorts and distribution of pigments, time and location of their occurrence and their changes during the egg development are characteristic of systematic groups.

Some egg show special shape in hatching pore.

Two types of the shape of the yolk in hatched larvae are observed: semiglobular (Pl. 1, Nos. 3, 6, 8, 10 and 15, Pl. 2, No. 4) and elongated (Pl. 2, Nos. 2, 6 and 10).

The Position of the Oil Globule in the newly Hatched Larvae

The newly hatched larvae with a single oil globule in the yolk can be divided into three groups: (1) The oil globule situated at the anterior part of the yolk (Pl. 1, No. 8: Pl. 2, No. 10), (2) at the lower part of the yolk (Pl. 1, No. 10) and (3) at the posterior part of the yolk (Pl. 1, No. 6: Pl. 2, No. 4). In these with many oil globules, they are usually scattered all over the yolk surface.

The position of the anus and its shift during larval development vary in the systematic groups.

The number of myotomes of hatched larvae is one or two more than the vertebral number of the species.

Some hatched larvae have special structures in the marginal fin (Pl. 1, Nos. 3 and 6: Pl. 2, Nos. 11 and 12) and some have ventral fins or dorsal fin rays when newly hatched (Pl. 1, Nos. 12 and 13; Pl. 2, No. 13).

The keys to 246 species of the pelagic fish eggs found in the adjacent waters of Japan are summarized as follows:

a^1 The spawned eggs are either imbedded in the gelatinous substance or they are agglutinated to each other forming an egg mass .....

..... Agglutinated pelagic eggs.

a^2 The spawned eggs are isolated, not forming any mass .....
..... Isolated pelagic eggs.

Agglutinated pelagic eggs (Pl. 1, Nos. 1–8)

a^1 The eggs are spawned in a gelatinous ribbon ..... 4 spp.

a^2 The eggs are spawned in a gelatinous balloon ..... 4 spp.

a^3 The eggs are agglutinated to each other, not imbedded in a gelatinous substance ..... 2 spp.

Isolated pelagic eggs (Pl. 1, Nos. 9–15, Pl. 2, Nos. 1–15)

a^1 The eggs with a single oil globule (rarely separated into 2–5) ..... (I).

a^2 The eggs without oil globule ..... (II).

a^3 The eggs with many oil globules (rarely united into one during the course of the egg development) ..... (III).

(I), (II) and (III) can be divided respectively into following four groups.

a^1 Egg membrane with markings, coating or appendages ..... A.

a^2 Egg membrane without above mentioned structures.

b^1 Perivitelline space narrow.

c^1 Yolk segmented ..... B.

c^2 Yolk not segmented ..... C.

b^2 Perivitelline space wide ..... D.

Number of species belonging to each groups of A-D are as follows:

I. A: 7 spp., I. B: 32 spp., I. C: 105 spp., I. D: 6 spp., II. A: 11 spp., II. B: 5 spp., II. C: 22 spp., II. D: 10 spp., III. A: 4 spp., III. B: 7 spp., III. C: 17 spp., III. D: 10 spp.

The detailed keys and the concerning literature will be given later.

Plate 1

Antennarius sp.

1 Freshly spawned egg veil, 70×70 mm
2 Imbedded eggs in hexagonal or pentagonal compartments, 0.7–0.8×0.6–0.7 mm in diameter
3 Larva newly hatched, 1.32 mm in total length

Pterois lunulata TEMMINCK et SCHLEGEL

4 Egg balloon, ca. 200×150 mm
5 Shortly before hatching, 0.82 mm in diameter, oil globule 0.17 mm
6 Larva newly hatched, 1.58 mm in total length

Unknown species

7 Floating egg mass, egg diameter 1.27–1.31×1.20–1.21 mm, oil globule 0.29 mm
8 Larva newly hatched, 3.02 mm in total length

Konosirus punctatus (TEMMINCK et SCHLEGEL)

9 6–7 hours before hatching, 1.54 mm in diameter, oil globule 0.12 mm
10 Larva newly hatched, 3.76 mm in total length

Trachinicae *gen* sp.

11 15 hours before hatching, 1.26 mm in diameter, oil globules 0.04–0.14 mm
12 Larva 1 day old, 3.88 mm in total length
13 Ditto, dorsal view, shows the ventral fins

Aesopia cornuta KAUP?

14 12 hours before hatching, 1.60 mm in diameter, oil globules 0.03–0.06 mm, hexagonal meshes of the egg membrane 0.18–0.24 mm
15 Larva newly hatched, 4.32 mm in total length

Plate 2

Engraulis japonica (HOUTTUYN)

1 Just before hatching, 1.4×0.7 mm in diameter
2 Larva newly hatched, 3.02 mm in total length

Mylio macrocephalus (BASILEWSKY)

3 20-myotome stage, 0.9 mm in diameter, oil globule 0.2 mm
4 Larva newly hatched, 1.9 mm in total length

Myctophina *gen* sp.

5 Embryo formation, 1.37 mm in diamter, oil globules 0.03–0.15 mm, appendages of the egg membrane 0.06×0.15 mm
6 Larva newly hatched, 4.98 mm in total length

Stethojulis kalosoma (BLEEKER)

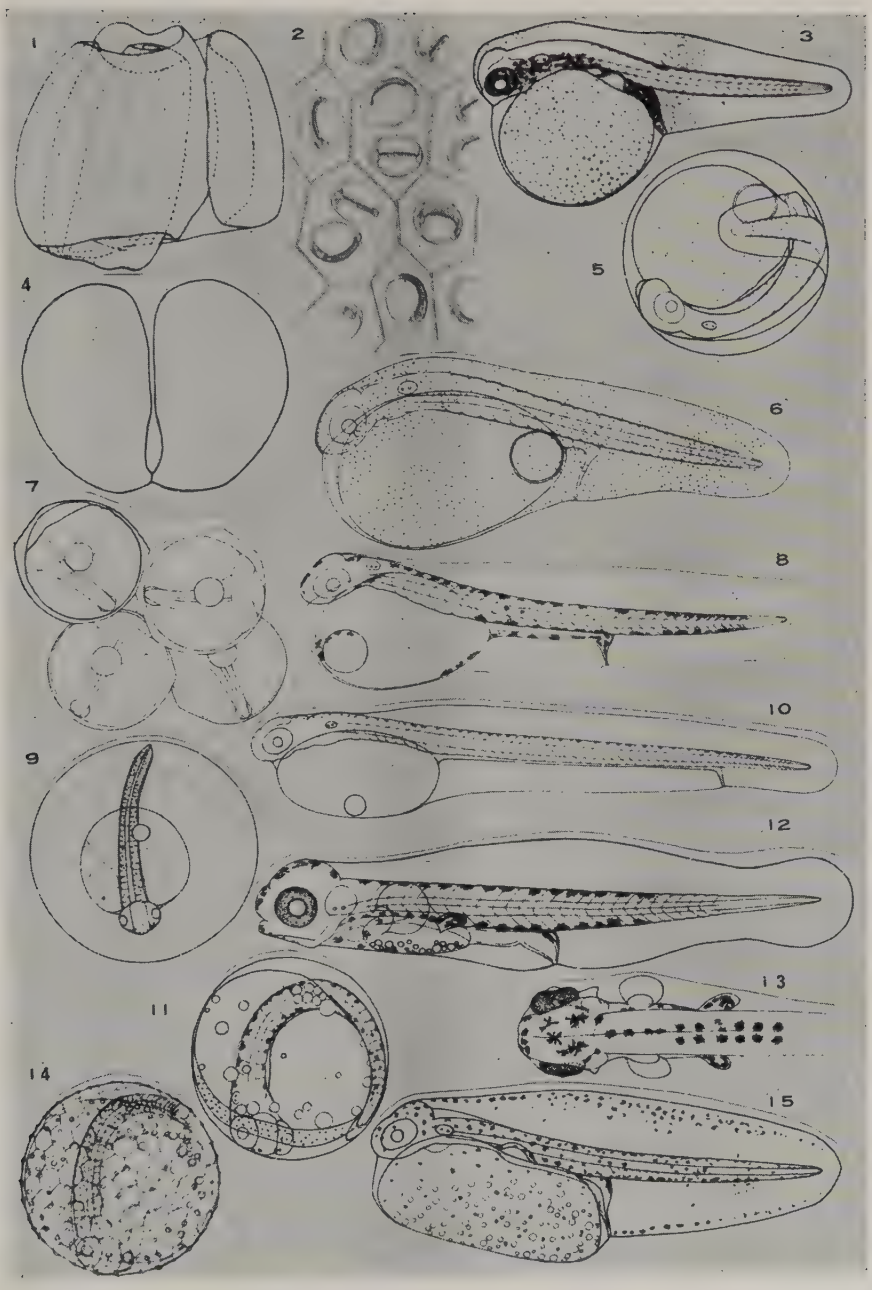
7 Embryo formation, 0.64 mm in diameter, oil globule 0.12 mm
8 Just before hatching
9 Empty egg capsule
10 Larva newly hatched, 1.53 mm in total length
11 Larva 1 day old, 2.00 mm in total length
12 Larva 3 days old, 2.02 mm in total length

Trachipterus sp.

13 1–1.5 days before hatching, 1.78 mm in diameter

Ophichthidae *gen* sp.

14 5–11 hours before hatching, 2.90 mm in diameter
15 Larva 4 days old, 13.2 mm in total length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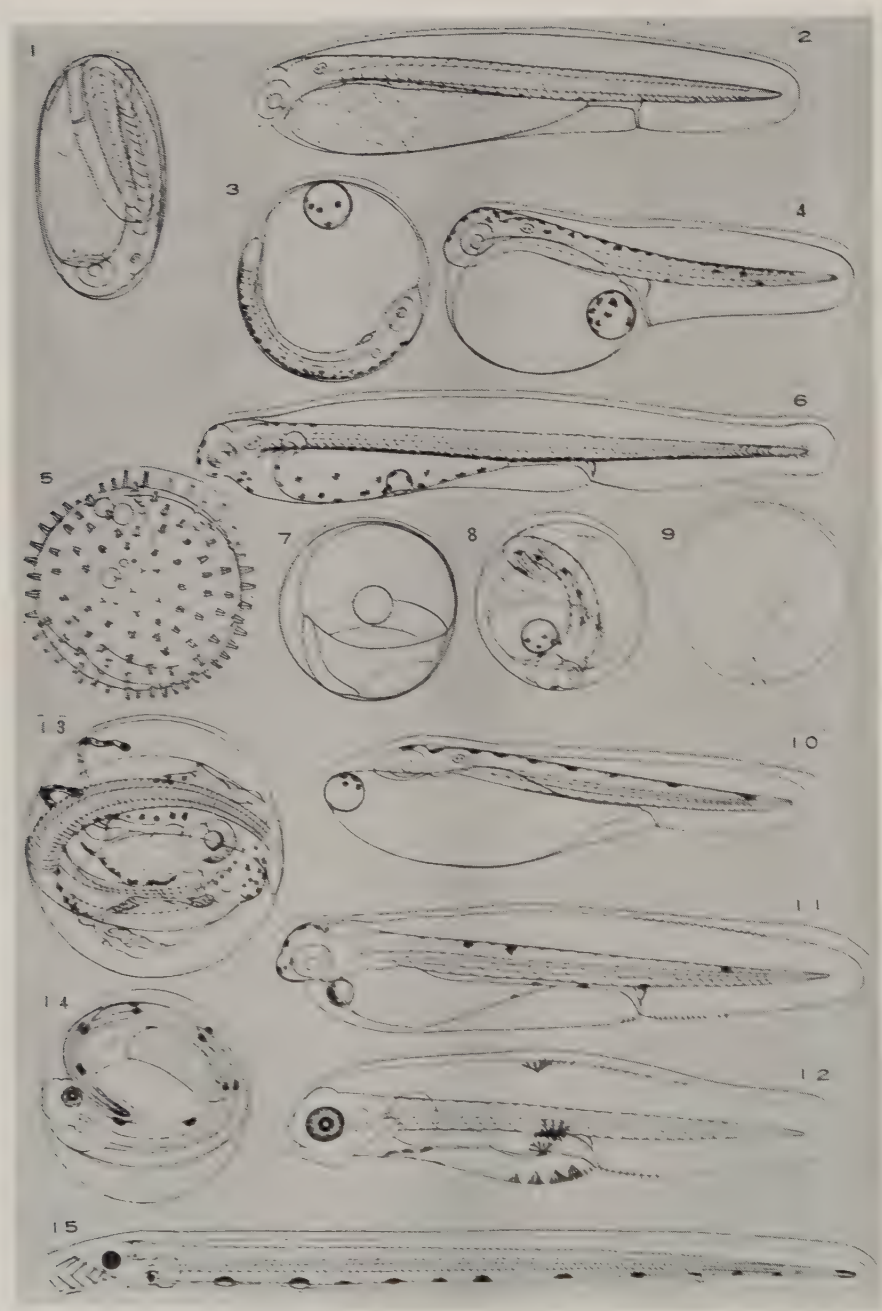
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A PRELIMINARY NOTE ON THE FISH LARVAE FOUND IN THE NORTH-WESTERN WATERS OF KYUSHU

By

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The authors began collecting fish larvae in the north-western waters of Kyushu to make clear the seasonal abundance and species composition. As the work is now going on, only a brief summary of the work is given in the present paper.

1. Tide pool collection

Mainly carried out at Gotō Islands, Nagasaki Prefecture and Tsuyazaki, Fukuoka Prefecture in summer.

2. Collections of the fish larvae accompanying floating algae

The collections were made about once a month off Tsuyazaki. The seasonal abundance was much the same as the results reported by Uchida and Shojima (1958).

3. Tow net collections

Simultaneous horizontal towing at the surface as well as at about 20 m depth with the 1 m larval net for 5 minutes at about 2 knots. Though the efficiency of the catch of the hauls at the surface and at 20 m depth could not be considered the same, in some species clear differences were seen in their occurrence or abundance.

The species collected by above mentioned methods are shown in the following list.

List of larval fishes collected from Western Kyushu

Scientific name	Japanese name
Etrumeus micropus (TEMMINCK et SCHLEGEL)	Urumeiwashi
Spratelloides japonicus (HOUTTUYN)	Kibinago
Sardinops melanosticta (TEMMINCK et SCHLEGEL)	Maiwashi
Engraulis japonica (HOUTTUYN)	Katakuchiiwashi
Gonorhynchus abbreviatus TEMMINCK et SCHLEGEL	Nezumigisu
Trachinocephalus myops (SCHNEIDER)	Okieso
Plotosus anguillaris (LACÈPÉDE)	Gonzui
Anguillida *gen* spp. (2 spp.)	
Ophichthidae *gen* sp.	

Uchida, K. and Y. Shojima, 1958. Studies on the larvae and juveniles of fishes accompanying floating algae—I. Research in the vicinity of Tsuyazaki, during Mar., 1957–Mar., 1958. Bull. Jap. Soc. Sci. Fish., 24(6–7) : 411–415 (in Japanese with English summary).

Ablennes anastomella (Cuvier et Valenciennes)	Datsu
Hemiramphus sajori (Temminck et Schlegel)	Sayori
Cololabis saira (Brevoort)	Sanma
Cypselurus opithopus hiraii Abe	Hosotobi
C. starksi Abe	Ariaketobiuo
Syngnathus schlegeli Kaup	Yōjiuo
Allanetta bleekeri (Günther)	Tōgorōiwashi
Scomber japonicus Houttuyn	Masaba
Coryphaena hippurus Linné	Shiira
Trachurus japonicus (Temminck et Schlegel)	Maaji
Seriola quinqueradiata Temminck et Schlegel	Buri
Leiognathus nuchalis (Temminck et Schlegel)	Hiiragi
Oplegnathus fasciatus (Temminck et Schlegel)	Ishidai
O. punctatus (Temminck et Schlegel)	Ishigakidai
Upeneus bensasi (Temminck et Schlegel)	Himeji
Apogon lineatus (Temminck et Schlegel)	Tenjikudai
Lateolabrax japonicus (Cuvier)	Suzuki
Plesiops melas Bleeker	Tanabatauo
Sillago japonica Temminck et Schlegel	Shirogisu
Girella punctata Gray	Mejina
Kyphosus cinerascens (Forskål)	Tenjikuisagi
Gerres oyena (Forskål)	Kurosagi
Evynnis japonica Tanaka	Chidai
Mylio macrocephalus (Basilewsky)	Kurodai
Chrysophrys major Temminck et Schlegel	Madai
Parapristipoma trilineatus (Thunberg)	Isaki
Therapon oxyrhynchus Temminck et Schlegel	Shimaisaki
Goniistius zonatus (Cuvier et Valenciennes)	Takanohadai
Uranoscopus japonicus Houttuyn	Mishimaokoze
Tripterigion etheostoma Jordan et Snyder	Hebiginpo
Dasson trossulus (Jordan et Snyder)	Nijiginpo
Enedrias nebulosus (Temminck et Schlegel)	Ginpo
Chasmichthys dolicognathus (Hilgendorf)	Agohaze
C. gulosus (Guichenot)	Dorome
Bathygobius fuscus (Rüppel)	Kumohaze
Aboma lactipes (Hilgendorf)	Ashishirohaze
Abdefduf vaigiensis (Quoy et Gaimard)	Oyabiicha
Stethojulis kalosoma (Bleeker)	Kaminaribera
Microcanthus strigatus (Cuvier et Valenciennes)	Kagokakidai
Siganus fuscescens (Houttuyn)	Aigo
Stephanolepis cirrhifer (Temminck et Schlegel)	Kawahagi
S. japonicus (Tilesius)	Yosogi
Rudarius ercodes Jordan et Fowler	Amimehagi
Navodon modestus (Günther)	Umazurahagi
Fugu niphobles (Jordan et Snyder)	Kusafugu
Sebastes inermis Cuvier et Valenciennes	Mebaru
Chelidonichthys kumu (Lesson et Garnot)	Hobo
Bothidae *gen* sp.	
Pterophryne histrio (Linné)	Hanaokoze

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A PRELIMINARY NOTE ON THE LIFE HISTORY OF THE ANADROMOUS UGUI MINNOW, *TRIBOLODON HAKONENSIS HAKONENSIS* (GÜNTHER) IN THE NORTHERN DISTRICT OF KYUSHU

By

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For several years the author has been studying the life history of the anadromous Ugui minnow, *Tribolodon hakonensis hakonensis* (Günther), mainly in the coast of Karatsu City, Saga Prefecture, northern Kyushu. The present paper deals with the data obtained up to present.

Although this fish is distributed, in northern Kyushu, from Karatsu Bay to Hakata Bay, and is known to aggregate in the mouth of the Rivers of Matsuura, Tamashima, Izumi, Zuibaiji and Muromi before spawning season, actual anadromous migration for spawning takes place only in the Matsuura River (rarely in the Tamashima River) because of the lack of the adequate spawning grounds in other rivers.

The spawning-season seems to extend from the end of January to the beginning of February in this river. When the water temperature approaches to approximate 10°C the adults aggregate in the brackish area of the river and migrate upstream 15 km from the mouth. The spawning takes place intensively, being affected by the water level. Natural spawning bed was not observed, because fishermen built artificial spawning beds with gravel for fishing in the whole spawning area.

The eggs are spawned among gravel, and are weakly adhesive and spherical in shape with yellow yolk, measuring about 2.5 mm in diameter.

The eggs hatched out in about one week in the spawning bed at the water temperature approximate 12°C. Newly hatched larvae are 6.5–7.1 mm in total length. The larvae attain about 10 mm in total length in two weeks, when they almost consume the yolk and swim out from the bed. The juvenile lives near the spawning ground. They stay in the fresh water area until the end of June when they attain about 50 mm in total length. At the end of July they attain about 79 mm in total length, and appear in the upper limit of the brackish area.

In October, the young Ugui minnow about 120 mm in total length is commonly seen in the mouth of this river, but they disappear there in November. Therefore, the migration of the young Ugui minnow to sea seems to be after November. A single specimen obtained from the drag-net off Karatsu City, November 20th 1959, was 137 mm in fork length.

The adult is found to live on the shallow sandy coast within 6 m in depth.

According to scale reading the spawning fish consisted of 2 to 4 age groups.

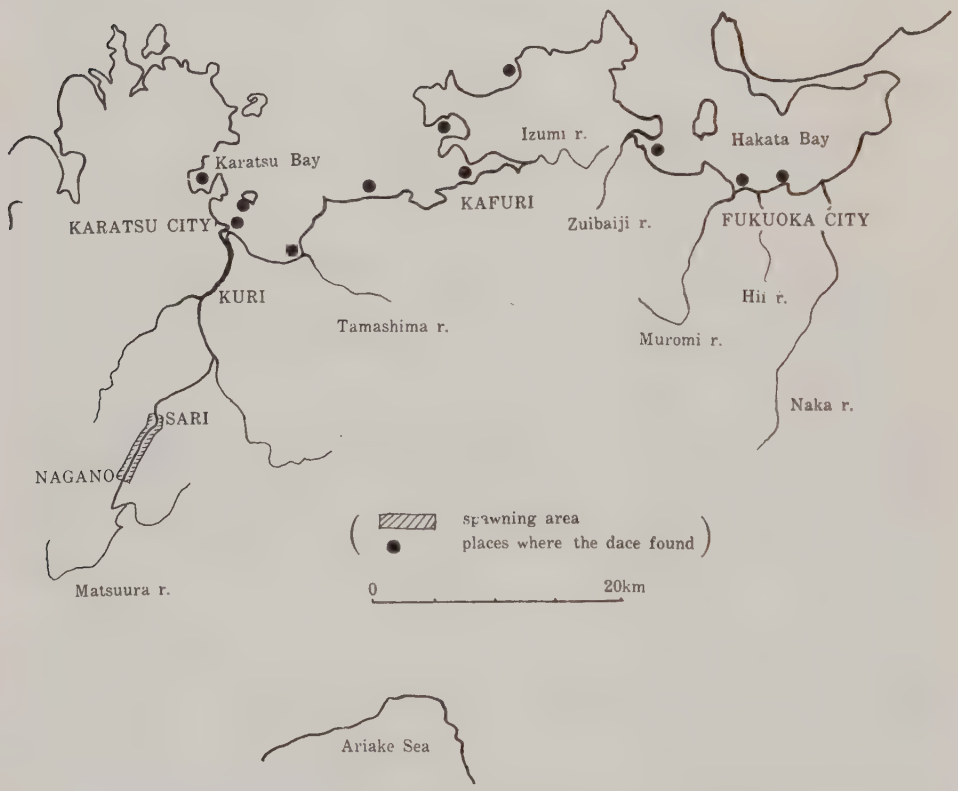

Figure. Distribution of the anadromous Ugui minnow, *Tribolodon hakonensis hakonensis* (Günther) in the northern district of Kyushu

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A LIST OF THE DECAPOD CRUSTACEA OF THE SEA OF ARIAKÉ, KYUSHU

By

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(Zoological Laboratory, Faculty of Agriculture, Kyushu University)

The Sea of Ariaké or Ariaké Bay lies on the east coast of Shimabara Peninsula, Kyushu, forming a large inland bay about 170,000 ha in area. Owing to its narraw entrance, the difference of ebb and flow is as high as six metres.

The Decapod fauna of the Sea of Ariaké has been reported by a few authors in the past. In 1900-05, Kishinouye described two new species of Macrura from the Sea of Ariaké, 1. *Parapenaeopsis cornuta* under the name *Penaeus cornutus*, 2. *Acetes japonicus*. Sakai (1939–56) described the following 13 species of Brachyura, 1. *Dorippe japonica* von Siebold, 2. *Pinnothers cyclinus* Shen, 3. *Pinnixa rathbuni* Sakai, 4. *Tritodynamia horvathi* Nobili, 5. *Tritodynamia intermedia* Shen, 6. *Xenophthalmus pinnotheroides* White, 7. *Uca arcuata* (de Haan), 8. *Uca marionis nitida* Dana, 9. *Camptandrium sexdentatum* Stimpson, 10. *Paracleistostoma cristatum* de Man, 11. *Ilyoplax deschampi* (Rathbun), 12. *Hemigrapsus sinensis* Rathbun, 13. *Sesarma erythrodactyla* Hess. The writer (1943) mentioned two species of Anomura, 1. *Porcellana serratifrons* Stimpson, 2. *Porcellana pulchra* Stimpson. Kubo (1947) described one species of Macrura, *Atypopenaeus compressipes* (Henderson). Ikematsu (1953–59) reported the following four species, 1. *Lucifer reynaudii* H. Milne Edwards, 2. *Metapenaeus monoceros* (Fabricius), 3. *Metapenaeus joyneri* (Miers), 4. *Palaemon macrodactylus* Rathbun. Six more species described by Yoshida (1960), namely, 1. *Penaeus japonicus* Bate, 2. *Penaeus monodon* Fabricius, 3. *Parapeneopsis tenella* (Bate), 4. *Metapenaeopsis barbata* (de Haan), 5. *Metapenaeopsis lamellata* (de Haan), 6. *Crangon affinis* de Haan. Twenty-eight species marked an asterisk are enumerated in these reports.

In the present paper an attempt is made to give a complete list of all the Decapod Crustacea known at present from the Sea of Ariaké. The materials dealt with came from the following sources: (1) a rich material of Anomura and Brachyura in the Seikai Regional Fisheries Research Laboratory collected in 1957–58, (2) some typical specimens of Macrura in the Shimonoseki College of Fisheries collected by Prof. H. Yoshida, (3) some specimens collected by Mr. T. Senda, (4) a private collection made by Mr. M. Matsuo, (5) the collections

in the Zoological Laboratory, Faculty of Agriculture, Kyushu University made from time to time by the writer and his students.

After the examination, 110 more species are added in the list as new to the fauna and one new species. Description of the new species will be published later. The total number of Decapod species from the Sea of Ariaké is counted at present 138 (29 Macrura, 13 Anomura, 96 Brachyura). In the list of the abbreviations cl. and cd. are used for "carapace length" and "carapace breadth" respectively.

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Decapoda

Macrura

1. Sergestidae

* (1) *Acetes japonicus* Kishinouye

Body-length: ♂ 24 mm, ♀ 30 mm. Abundant in the innermost part of the Sea of Ariaké. According to Ikamatsu (1953), there are two types of generations of this species in the Sea. The one that passed the winter dies after spawning between May and July. The other that hatched early in summer grows rapidly in warmer season, and spawning takes place early in August (First summer generation). The shrimps born from the first summer generation lay eggs in late September (Second summer generation), whole individuals of spent shrimps die after spawning.

* (2) *Lucifer reynaudii* H. Milne Edwards

Body-length: 9 mm. Collected by plankton nets.

2. Penaeidae

* (3) *Penaeus japonicus* Bate

Body-length: ♂ 160 mm, ♀ 170 mm. Off Shimabara; Minenotsu, Okinohata, collected by trawl nets. Spawning season: July to August.

* (4) *Penaeus monodon* Fabricius

Body-length: ♂ 170 mm, ♀ 175 mm. In the Sea of Ariaké, this shrimp is rarely found and collected together with the preceding species.

(5) *Penaeus semisulcatus* de Haan

Body-length: ♂ 200 mm, ♀ 190 mm. Rarely and cohabited with *Penaeus japonicus*.

* (6) *Metapenaeus monoceros* (Fabricius)

Body-length: 140 mm. Minenotsu, Okinohata. Spawning season: Early June to early September; peak: late June to Mid-August (Ikematsu, 1959).

(7) *Metapenaeus burkenroadi* Kubo

Body length: 115 mm. Minenotsu, Okinohata. Some specimens were taken from stomachs of *Pagrosomus major.*

* (8) *Metapenaeus joyneri* (Miers)

Body-length: 152 mm. Minenotsu, Okinohata; off Shimabara, collected by trawl nets. Spawning season: Late May to early September; peak: July to August (Ikematsu, 1955).

* (9) *Atypopenaeus compressipes* (Henderson)

Body-length: 43 mm. Off Shimabara, collected by trawl nets.

* (10) *Parapenaeopsis tenella* (Bate)

Body-length: 60 mm. Minenotsu, Okinohata; off Shimabara, collected by trawl nets. Spawning season: July to August.

* (11) *Parapenaeopsis cornuta* (Kishinouye)

Body-length: 50 mm. Sandy bottom, off Fukuoka and Kumamoto Prefectures.

(12) *Trachypenaeus curvirostris* (Stimpson)

Body-length: 80 mm. Off Shimabara, collected by trawl nets and also taken from stomachs of *Inimicus japonicus* and *Chelidonichthys kumu.* Spawning season: September to October.

* (13) *Metapenaeopsis barbata* (de Haan)

Body-length: 85 mm. Minenotsu, Okinohata. Some specimens were taken from stomachs of *Chelidonichthys kumu* and *Acanthogobius flavimanus.*

(14) *Metapenaeopsis acclivis* (Rathbun)

Body-length: 75 mm. Spawning season: July. Minenotsu, Okinohata; off Shimabara, collected by trawl nets.

* (15) *Metapenaeopsis lamellata* (de Haan)

Body-length: 65 mm. Off Shimabara, collected by trawl nets.

3. Pasiphaeidae

(16) *Leptochela gracilis* Stimpson

Body-length: 27 mm. Taken from stomachs of *Apogon lineatus.* and *Sillago sihama.*

4. Palaemonidae

(17) *Palaemon serrifer* (Stimpson)

Body-length: 45 mm. Collected on the shore of Shimabara. Egg-bearing season: February to March and June to August.

(18) *Palaemon japonicus* (Ortmann)

Body-length: 70 mm. Collected in tide-pools of the shores of Shimabara and Okinohata. Egg-bearing season: June.

* (19) *Palaemon macrodactylus* Rathbun

The innermost part and the central part of the Sea of Ariaké (Ikematsu, 1956). This species is not included in my collection.

(20) *Macrobrachium longipes* (Fabricius)

Body-length: 85 mm. River mouth of Okinohata, Yanagawa City.

5. Alpheidae

(21) *Alpheus brevicristatus* de Haan

Body-length: 53 mm. Takatsu, Okinohata; off Shimabara, collected by trawl nets. Egg-bearing season: Late August.

(22) *Alpheus japonicus* Miers

Body-length: 32 mm. Okinohata, Yanagawa City.

(23) *Alpheus bisincisus* de Haan

Body-length: 28 mm. Taken from a stomach of *Chaeturichthys hexanema*.

6. Ogyridae

(24) *Ogyrides striaticauda* Kemp

Hama, Saga Prefecture (Ikematsu's collection). This species is not included in my collection.

7. Hippolytidae

(25) *Heptacarpus rectirostris* (Stimpson)

Body-length: 35 mm. Collected at the shore of Shimabara.

(26) *Latreutes planirostris* (de Haan)

Body-length: 32 mm. Minenotsu, Okinahata; off Shimabara, collected by larva-nets and taken from a stomach of *Sebasticus marmoratus*.

8. Crangonidae

* (27) *Crangon affinis* de Haan

Body-length: 45 mm. Taken from stomachs of *Chelidonichthys kumu*. Egg-bearing season: January.

9. Callianassidae

(28) *Callianassa harmandi* Bouvier

Body-length: ♂ 51.5 mm, ♀ 37.8–50.5 mm. Sand-muddy bottom, off Arao City. Egg-bearing season. Late May to August.

(29) *Upogebia (Upogebia) major* (de Haan)

♀ cl. 21 mm, cb. 18.5 mm. Off Arao City, sandy and muddy flat, taken from stomachs of fishes, *Mustelus griseus*, *Chaeturichthys hexanema* and *Cryptocentrus filifer*.

Anomura

1. Galatheidae

(1) *Galathea orientalis* Stimpson

♂ cl. 4 mm, cb. 5 mm; ovig. ♀ cl. 5 mm, cb. 5 mm. Egg-bearing

season: June to August and September to March.

2. Porcellanidae

(2) *Petrolisthes japonicus* (de Haan)

♂ 10.5 mm, cb. 9 mm; ovig. ♀ cl. 9 mm, cb. 9 mm. Egg-bearing season: July to August.

* (3) *Pisidia serratifrons* Stimpson

♂ cl. 5.5 mm, cb. 5 mm; ♀ cl. 6.5 mm, cb. 6.5 mm; ovig. ♀ cl. 4.5 mm, cb. 4.5 mm. Egg-bearing season: July to August. Abundant in the central part of the Sea of Ariaké.

* (4) *Porcellana pulchra* Stimpson

♂ cl. 7 mm, cb. 5 mm; ovig. ♀ cl. 3.5 mm, cb. 3.3 mm–cl. 5.5 mm, cb. 6 mm. Egg-bearing season: September.

(5) *Polyonyx utinomii* Miyake

♀ cl. 6.5 mm, cb. 9.5 mm. Rarely found in the Sea of Ariaké.

3. Paguridae

(6) *Paguristes* sp. nov.

♂ cl. 6 mm, cb. 3.5 mm. Taken in the central part of the Sea.

(7) *Diogenes edwardsii* (de Haan)

♂ cl. 27 mm, cb. 18 mm; ♀ cl. 30 mm, cb. 28 mm; ovig. ♀ cl. 16 mm, cb. 10 mm. Taken from the stomach of *Mustelus manazo*.

(8) *Diogenes nitidimanus* Terao

♂ cl. 13 mm, cb. 11 mm; ♀ 9 mm, cb. 6 mm. Nishinotsu, Okinohata, Fukuoka Prefecture.

(9) *Pagurus dubius* (Ortmann)

♂ cl. 3.5 mm, cb. 2.5 mm; ♀ cl. 2.5 mm, cb. 2 mm.

(10) *Pagurus megalops* (Stimpson)

♀ cl. 11 mm, cb. 8 mm. Rarely found in the Sea.

(11) *Pagurus lanuginosus* de Haan

♂ cl. 7 mm, cb. 4.5 mm; ♀ cl. 10.5 mm, cb. 6.5 mm.

(12) *Pagurus constans* (Stimpson)

♂ cl. 12 mm, cb. 14 mm. Rarely found in the Sea.

(13) *Spiropagurus spiriger* (de Haan)

♂ cl. 16 mm, cb. 14 mm; ♀ cl. 12 mm, cb. 11 mm. Egg-bearing season: September.

Brachyura

1. Dromiidae

(1) *Petalomera japonica* (Henderson)

♂ cl. 10 mm, cb. 9.5 mm. Off north coast of Yushima Islet.

(2) *Conchoecetes artificiosus* (Fabricius)

Taken at the river mouth of Hama, Saga Prefecture.

2. Dorippidae

* (3) *Dorippe japonica* von Siebold

♂ cl. 23 mm, cb. 19 mm; ovig. ♀ cl. 23 mm, cb. 25.5 mm. Off Arao City; Nanaura, Kashima City. Collected by a shrimp trawl. Egg-bearing season: Late May in Amakusa.

(4) *Dorippe dorsipes* (Linnaeus)

♂ cl. 24 mm, cb. 26 mm; ♀ cl. 30 mm, cb. 34 mm. Egg-bearing season: Late June in Amakusa.

(5) *Dorippe granulata* de Haan

♂ cl. 5.5 mm, cb. 5 mm; ovig. ♀ cl. 15 mm, cb. 16 mm. Taken from stomachs of the fish, *Mustelus manazo* and collected at the most deep bottom in the middle of the Sea of Ariaké. Egg-bearing season: Mid-September.

3. Calappidae

(6) *Matuta lunaris* (Forskål)

♂ cl. 44.5 mm, cb. 43.5 mm. Collected at Ujiguchi, Kumamoto Prefecture.

(7) *Matuta planipes* Fabricius

♂ cl. 44 mm, cb. 60 mm; ovig. ♀ 25.5 mm, cb. 35.5 mm. Off Arao City; off Okinohata, Yanagawa City. Egg-bearing season: Mid-August.

4. Leucosiidae

(8) *Orephorus (Oreotlos) latisoides* Sakai

♂ cl. 3 mm, cb. 4 mm; ♀ cl. 6 mm, 10 mm.

(9) *Nursia elegans japonica* Sakai

♂ cl. 3.5 mm, cb. 3.8 mm; ♀ cl. 8.8 mm, cb. 9.3 mm; ovig. ♀ cl. 4 mm, cb. 5 mm. Egg-bearing season: August to September.

(10) *Arcania undecimspinosa* de Haan

♂ cl. 15 mm, cb. 14 mm; ovig. ♀ cl. 21 mm, cb. 20 mm. Abundant in the Sea and also taken from stomachs of the fish, *Mustelus manazo*. Egg-bearing season: September.

(11) *Arcania globata* Stimpson

♂ cl. 7.5 mm, cb. 7.3 mm; ♀ cl. 13 mm, cb. 10.5 mm; ovig. ♀ cl. 7 mm, cb. 6 mm. Egg-bearing season: January to April in Amakusa.

(12) *Arcania heptacantha* (de Haan)

♂ cl. 19 mm, cb. 19 mm; ♀ cl. 19 mm, cb. 22 mm. Taken from stomachs of *Mustelus manazo*. Ovigerous females were taken from the Sea of Ariaké in the mid-September, but taken from Amakusa in July to August.

(13) *Myra fugax* (Fabricius)

♂ cl. 32 mm, cb. 25 mm; ♀ cl. 33 mm, cb. 26.5 mm. Abundant in the Sea and also taken from stomachs of fishes, *Chelidonichthys kumu* and *Mustelus manazo*. Egg-bearing season: July to September.

(14) *Cryptocnemus pentagonus* Stimpson

♂ cl. 16 mm, cb. 23 mm; ovig. ♀ cl. 12.5 mm, cb. 17 mm. Egg-bearing season: Mid-September.

(15) *Leucosia longifrons* de Haan

♂ cl. 17 mm, cb. 15 mm; ♀ cl. 24 mm, cb. 20.5 mm; ovig. ♀ cl. 26.5 mm cb. 24.5 mm. Egg-bearing season: Mid-September.

(16) *Leucosia haematosticta* Adams and White

♂ cl. 11.5 mm, cb. 11 mm; ♀ cl. 8 mm, cb. 7.6 mm. This species is widely distributed in the Sea of Ariaké and also taken from stomachs of *Mustelus manazo*.

(17) *Leucosia rhomboidalis* de Haan

♂ cl. 22 mm, cb. 19 mm; ovig. ♀ cl. 16 mm, cb. 13.5 mm. Taken at Aratsu, Okinohata, Yanagawa City, and from stomachs of *Mustelus manazo*. Egg-bearing season: September.

(18) *Leucosia vittata* Stimpson

♂ cl. 11 mm, cb. 9 mm; ♀ cl. 11 mm, cb. 10 mm.

(19) *Leucosia craniolaris* (Linnaeus)

♂ cl. 24 mm, cb. 21 mm, Aratsu, Okinahata, Yanagawa City. Egg-bearing season: May in Amakusa.

(20) *Philyra platycheira* de Haan

♂ cl. 16 mm, cb. 15 mm; ovig. ♀ cl. 14 mm, cb. 12 mm. Kawajiri, Hama, Saga Prefecture and taken from stomachs of fishes, *Pagrosomus major* and *Chelidonichthys kumu*. Egg-bearing season: January to April.

(21) *Philyra hetrograna* Ortmann

♂ cl. 15 mm, cb. 14 mm; ♀ cl. 16 mm, cb. 16 mm.

(22) *Philyra pisum* de Haan

♂ cl. 21 mm, cb. 21 mm. Egg-bearing season: Late May.

5. Hymenosomidae

(23) *Trigonoplax unguiformis* (de Haan)

♂ cl. 6 mm, cb. 10 mm; ovig. ♀ cl. 17.5 mm, cb. 16.8 mm. Egg-bearing season: May and early December.

6. Majidae

(24) *Paratymolus pubescens* Miers

♂ cl. 4 mm, cb. 2.5 mm; ♀ cl. 7.5 mm, cb. 6.3 mm.

(25) *Achaeus japonicus* de Haan

♂ cl. 9 mm, cb. 9 mm; ♀ cl. 6 mm, cb. 6 mm; ovig. ♀ cl. 4.2 mm, cb. 4.6 mm. Egg-bearing season: March to April and September.

(26) *Achaeus tuberculatus* Miers

♂ cl. 9 mm, cb. 9 mm; ♀ cl. 6 mm, cb. 5 mm; ovig. ♀ cl. 5 mm, cb. 4 mm. Abundant in the Sea and taken from stomachs of the fish, *Mustelus manazo*.

(27) *Pugettia incisa* (de Haan)

♂ cl. 7.5 mm, cb. 6.5 mm; ♀ cl. 8 mm, cb. 7.5 mm; ovig. ♀ cl. 7.5 mm, cb. 6.5 mm. Egg-bearing season: November to December.

(28) *Pugettia minor* Ortmann

Only one male was taken at the entrance of the Sea of Ariaké.

(29) *Pugettia nipponensis* Rathbun

♂ cl. 17 mm, cb. 16 mm. Rarely found in the Sea.

(30) *Hyastenus diacanthus* (de Haan)

♂ cl. 36.5 mm, cb. 30 mm; ♀ cl. 32 mm, cb. 26 mm; ovig. ♀ cl. 28 mm, cb. 27 mm. Egg-bearing season: September and November.

(31) *Micippa thalia* (Herbst)

♂ cl. 21 mm, cb. 18 mm; ovig. ♀ cl. 15 mm, cb. 14 mm. Egg-bearing season: Late August.

7. Parthenopidae

(32) *Lambrus (Platylambrus) validus* de Haan

♂ cl. 46 mm, cb. 35 mm; ovig. ♀ cl. 22 mm, cb. 38 mm-cl. 36 mm, cb. 31.5 mm. This species is widely distributed in the Sea of Ariaké, and taken from stomachs of *Mustelus manazo*. Egg-bearing season: Mid-September.

8. Euryalidae

(33) *Jonas distincta* (de Haan)

♂ cl. 25 mm, cb. 17 mm. Rarely found in the Sea of Ariaké.

9. Portunidae

(34) *Macropipus corrugatus* (Pennant)

♂ cl. 23 mm, cb. 27 mm; ♀ cl. 22 mm, 24 mm.

(35) *Portunus gladiator* Fabricius

♂ cl. 59 mm, cb. 86 mm; ♀ cl. 40 mm, cb. 70 mm.

(36) *Portunus hastatoides* Fabricius

♂ cl. 18.5 mm, cb. 27 mm; ♀ cl. 21 mm, cb. 23 mm. Abundant in the Sea of Ariaké and taken from stomachs of fishes, *Mustelus manazo, Pterois lunulata* and *Sphaeroides niphobles*. Egg-bearing season: Early August.

(37) *Potunus trituberculatus* (Miers)

♂ cl. 70 mm, cb. 135 mm; ♀ cl. 67 mm, cb. 123 mm. Ujiguchi, Kumamoto Prefecture.

(38) *Scylla serrata* (Forskål)

This species is rarely found in the Sea of Ariaké.

(39) *Charybdis variegata* (Fabricius)

♂ cl. 22 mm, cb. 34 mm; ♀ cl. 13 mm, cb. 20 mm. Egg-bearing season: August to September.

(40) *Charybdis bimaculata* (Miers)

♂ cl. 11 mm, cb. 16 mm. Taken from a stomach of the fish, *Mustelus manazo*. Egg-bearing season: Mid-August.

(41) *Charybdis truncata* (Fabricius)

♂ cl. 16 mm, cb. 22 mm; ♀ cl. 8.5 mm, cb. 12 mm.

(42) *Charybdis japonica* (A. Milne Edwards)

♂ cl. 80 mm, cb. 95 mm; ♀ cl. 66 mm, cb. 80 mm; ovig. ♀ cl. 47 mm, cb. 64 mm. Ujiguchi, Kumamoto Prefecture. Egg-bearing season: August.

10. Cancridae

(43) *Cancer gibbosulus* (de Haan)

♂ cl. 14 mm, cb. 17 mm; ♀ cl. 19 mm, cb. 26 mm. This species appears to be very common in the Sea of Ariaké, some specimens having been taken from stomachs of *Mustelus manazo*.

11. Xanthidae

(44) *Halimede fragifera* de Haan

♂ cl. 16 mm, cb. 20 mm; ovig. ♀ cl. 24 mm, cb. 30 mm. Egg-bearing season: Mid-September.

(45) *Medaeus granulosus* (Haswell)

♂ cl. 15 mm, cb. 21 mm. Rarely found in the Sea of Ariaké.

(46) *Xantho distinguendus* de Haan

♂ cl. 17 mm, cb. 26 mm; ♀ cl. 13.5 mm, cb. 20 mm. Collected on sandy and muddy flats exposed at low tide of Arao City, Okinohata and Shimabara Peninsula.

(47) *Actaea savignyi* (H. Milne Edwards)

♂ cl. 22 mm, cb. 28 mm; ovig. ♀ cl. 11.3 mm, cb. 15 mm. Egg-bearing season: Mid-September.

(48) *Actumnus squamosus* (de Haan)

♂ cl. 11 mm, cb. 14 mm; ovig. ♀ cl. 7 mm, cb. 10 mm–cl. 12 mm, cb. 14.5 mm. Muddy and sandy flats, Aratsu, Okinohata, Yanagawa City. Egg-bearing season: September and November.

(49) *Actumnus setifer* (de Haan)

♂ cl. 10 mm, cb. 12 mm; ♀ cl. 8 mm, cb. 10 mm.

(50) *Pilumnus minutus* de Haan

♂ cl. 10 mm, cb. 13 mm; ovig. ♀ cl. 3.5 mm, cb. 4 mm–cl. 5.8 mm, cb. 8 mm. Egg-bearing season: Mid-September.

(51) *Heteropilumnus ciliatus* (Stimpson)

♂ cl. 6.5 mm, cb. 8 mm; ♀ cl. 3.5 mm, cb. 5 mm.

(52) *Pilumnopeus makianus* (Rathbun)

♂ cl. 8.5 mm, cb. 12 mm; ♀ cl. 7 mm, cb. 11 mm. On sandy and muddy flats exposed at low tide, off Tara, Saga Prefecture and Aratsu, Okinohata, Yanagawa City, shore collecting.

(53) *Calmania prima* Laurie

♂ cl. 9 mm, cb. 8 mm; ovig. ♀ cl. 9 mm, cb. 9 mm. Egg-bearing season: Early August.

12. Goneplacidae

(54) *Carcinoplax vestita* (de Haan)

♂ cl. 9 mm, cb. 13 mm; ♀ cl. 16 mm, cb. 21 mm. Some specimens were taken from stomachs of *Mustelus manazo*.

(55) *Hetreoplax nagasakiensis* Sakai

♂ cl. 6 mm, cb. 10 mm; ♀ cl. 6.5 mm, cb. 11 mm. Very common in the Sea of Ariaké and having been also taken from stomachs of *Mustelus manazo*.

(56) *Eucrate crenata* de Haan

♂ cl. 29 mm, cb. 34 mm; ♀ cl. 29 mm, cb. 36 mm; ovig. ♀ cl. 18 mm, cb. 22 mm. Egg-bearing season: September. A bundant in the Sea of Ariaké.

(57) *Homoioplax haswelli* (Miers)

♂ cl. 6 mm, cb. 7 mm. Seldom seen in the Sea of Ariaké.

(58) *Typhlocarcinus villosus* Stimpson

♂ cl. 6 mm, cb. 8 mm; ♀ cl. 6 mm, cb. 8 mm.

(59) *Typhlocarcinops canaliculata* Rathbun

♂ cl. 11 mm, cb. 13 mm; ♀ cl. 12 mm, cb. 15 mm.

(60) *Mertonia lanka* Laurie

♂ cl. 7 mm, cb. 9 mm; ovig. ♀ cl. 6 mm, cb. 7 mm. Off Shimabara Peninsula. Egg-bearing season: Mid-August.

(61) *Lamdophallus anfractus* Rathbun

♂ cl. 7 mm, cb. 11 mm; ♀ cl. 8 mm, cb. 13 mm. Muddy bottom, mouth of Midori River. This species is commensal with *Protankyra bidentata* living in muddy bottom at Tomioka, Amakusa.

13. **Pinnotheridae**

(62) *Pinnotheres cardii* Bürger

♀ cl. 6.5 mm. Off Okinahata, Yanagawa City, commensal in the matle cavity of *Meretrix meretrix*.

* (63) *Pinnotheres cyclinus* Shen

Commensal with *Venerupis (Amygdala) japonica*.

(64) *Pinnotheres gordoni* Shen

Shidoko, Saga Prefecture, collected by a larva-net; river mouth of Hama, Saga Prefecture and also commensal with *Venerupis japonica*.

(65) *Pinnixa haematosticta* Sakai

♀ cl. 1.6 mm, cb. 4 mm.

* (66) *Pinnixa rathbuni* Sakai

♀ cl. 6 mm, cb. 11 mm; ♀ cl. 8 mm, cb. 13 mm. Mouth of Rokkaku river, Saga Prefecture, collected by a larva-net; many crabs were collected on sandy and muddy flat exposed at low tide, Nishinotsu, Okinohata, Yanagawa City, cohabiting with *Volsella metcalfei* and *Lomia medusa*. This species is usually commensal in the tube of the latter. Some specimens are taken from stomachs of *Acanthogobius hasta* and *Mustelus manazo*.

(67) *Pinnixa penultipedalis* Stimpson

♀ cl. 4 mm, cb. 7.5 mm. Commensal in a tube of *Lomia medusa*.

(68) *Asthenognathus inaequipes* Stimpson

♂ cl. 6 mm, cb. 10 mm; ♀ cl. 10 mm, cb. 12 mm. Abundant on muddy bottom of the innermost part of the Sea of Ariaké. Some specimens are taken from stomachs of *Platycephalus indicus*.

(69) *Tritodynamia japonica* Ortmann

♂ cl. 9 mm, cb. 13 mm; ♀ cl. 4 mm, cb. 9 mm. Many specimens were taken in the innermost and central parts of the Sea of Ariaké. Egg-bearing season: Mid-September.

(70) *Tritodynamia rathbuni* Shen

♂ cl. 6 mm, cb. 10 mm; ♀ cl. 10 mm, cb. 21 mm; ovig. ♀ cl. 11 mm, cb. 16 mm. Some specimens were take in tubes of *Chaetopterus variopedatus* inhabiting on muddy flats of Tara, Saga Prefecture and also taken in tubes of *Lomia medusa* at Furbe, Shimabara Peninsula. Some were obtained from stomachs of *Mustelus manazo*. Egg-bearing season: Early April to May.

* (71) *Tritodynamia horvathi* Nobili

♀ cl. 6 mm, cb. 10 mm; ♀ cl. 7 mm, cb. 10 mm. This species is very common in the Sea of Ariaké; occasional migrations of a great many crabs have appeared, but I have not examined them since the last one occurred in May to August, 1947.

Although this crab of the Sea of Ariaké is called "Miroku-Gani" meaning an inhabitant in the matle cavity of a bivalve shell, "Miroku-Gai" or "Sarubo", *Anadara (Scapharca) subrenata* (Lischke), I have not yet an occasion to examine its cohabitation. Some specimens were taken in the tubes of a kind of polychaete, *Lomia medusa* (Matsuo, 1957), but its life-history is not studied sufficiently. The crabs are used for manure in the districts of Ariaké.

* (72) *Tritodynamia intermedia* Shen

♂ cl. 6 mm, cb. 9 mm; ♀ cl. 6 mm, cb. 10 mm. A few crabs of this species are found together with the preceeding species. Some specimens were taken in the tubes of *Lomia medusa* at Yamada, Shimabara Peninsula.

* (73) *Xenophthalmus pinnotheroides* White

♂ cl. 7 mm, cb. 10 mm; ♀ cl. 10 mm. cb. 14 mm; ovig. ♀ cl. 6 mm, cb. 8 mm-cl. 10 mm, cb. 13 mm. Very common in the innermost part of the Sea of Ariaké. Egg-bearing season: Mid-September.

14. Ocypodidae

* (74) *Uca arcuata* (de Haan)

♂ cl. 22 mm, cb. 35 mm, body-weight 17 g; ♀ cl. 20 mm, cb. 31.5 mm, bw. 10 g. The species are utilized for salted crabs, "Gani-Zuké" or "Kani-Zuké" and used for food in the districts of Ariaké.

* (75) *Uca marionis nitida* Dana

The Sea of Ariaké (Sakai, 1956). This species is not included in my collection.

* (76) *Camptandrium sexdentatum* Stimpson

♂ cl. 6.3 mm, cb. 7.8 mm; ♀ cl. 5.3 mm, cb. 7.4 mm. Taken from the stomachs of *Platycephalus indicus*. Egg-bearing season: August.

(77) *Macrophthalmus dilatatus* de Haan

♂ cl. 12 mm, cb. 25 mm. In the districts of Ariaké, this species is called "Yokota-Gani and Medaka-Gani" and used for salted crabs, but not so good material as the crab, *Uca arcuata*.

(78) *Macrophthalmus japonicus* de Haan

♂ cl. 20 mm, cb. 32 mm; ♀ cl. 21 mm, cb. 31 mm. Nishinotsu, Okinohata, Yanagawa City. This crab is found together with *Volsella metcalfei* and *Lomia medusa*.

(79) *Cleistostoma dilatatum* de Haan

♂ cl. 12 mm, cb. 18.5 mm; ♀ cl. 10 mm, cb. 15.5 mm.

* (80) *Paracleistostoma cristatum* de Man

♂ cl. 9.5 mm, cb. 15 mm; ovig. ♀ cl. 11 mm, cb. 17 mm. Egg-bearing season: Mid-October to late March.

* (81) *Ilyoplax deschampi* (Rathbun)

Mouth of Chikugo River (Sakai, 1956). It has never been collected by me in the districts of Ariaké.

(82) *Ilyoplax pusilla* (de Haan)

♂ cl. 7 mm, cb. 9.3 mm; ♀ cl. 6 mm, cb. 8 mm. Sandy and muddy flat of river mouth, off Yanagawa City and Arao City.

15. Grapsidae

(83) *Eriocheir japonicus* (de Haan)

♂ cl. 75 mm, cb. 81 mm; ♀ cl. 64 mm, cb. 72 mm. The downstream migration of this crab commences in upper course in the mid-August and continues in its lower course into November. Egg-bearing season: End of September to early June.

(84) *Hemigrapsus penicillatus* (de Haan)

♂ cl. 29 mm, cb. 31 mm; ♀ cl. 25 mm, cb. 28 mm.

(85) *Hemigrapsus sanguineus* (de Haan)

Ovig. ♀ cl. 25 mm, cb. 29 mm. Off Okinohata, Yanagawa City and Arao City. Egg-bearing season: August.

* (86) *Hemigrapsus sinensis* Rathbun

Muddy flat exposed at low tide in Tara, Saga Prefecture. Egg-bearing season: May.

(87) *Goetice depressa* (de Haan)

♂ cl. 24 mm, cb. 29 mm; ♀ cl. 26 mm, cb. 28 mm; ovig. ♀ cl. 11 mm, cb. 12.5 mm. Aratsu, Okinohata, Yanagawa City. Egg-bearing season: August.

(88) *Sesarma (Holometopus) haematocheir* (de Haan)

♂ cl. 30 mm, cb. 37 mm; ♀ cl. 27 mm, cb. 30 mm.

(89) *Sesarma (Holometopus) dehaani* H. Milne Edwards

♂ cl. 48 mm, cb. 43 mm; ♂ cl. 36 mm, cb. 40 mm.

(90) *Sesarma (Parasesarma) plicata* (Latreille)

♂ cl 28 mm, cb. 32 mm; ♀ cl. 21 mm, cb. 27 mm.

* (91) *Sesarma (Parasesarma) erythrodactyla* Hess

♂ cl. 15 mm, cb. 19.5 mm; ♀ cl. 13 mm, cb. 16 mm.

(92) *Sesarma (Sesarma) intermedia* (de Haan)

♂ cl. 29 mm, cb. 33 mm; ♀ cl. 29 mm, cb. 32 mm.

(93) *Sesarma gordoni* Shen

♂ cl. 7 mm, cb. 8 mm; ovig. ♀ cl. 5.8 mm, cb. 6.5 mm. Aratsu, Okinohata, Yanagawa City. Egg-bearing season: August.

(94) *Chasmagnathus convexus* (de Haan)

♂ cl. 42 mm, cb. 57 mm, body-weight 75 g; ♀ cl. 35.2 mm, cb. 45 mm, bw. 37.2 g; ovig. ♀ cl. 32 mm, cb. 41 mm. Egg-bearing season: December.

(95) *Helice tridens tridens* de Haan

♂ cl. 27 mm, cb. 31 mm; ♀ cl. 29 mm, cb. 35 mm. Off Arao City.

(96) *Clistocoeloma merguiense* de Man

♂ cl. 12 mm, cb. 14.5 mm; ♀ cl. 9 mm, cb. 12 mm.

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THE FLOATING SEAWEEDS OF THE SEA TO THE WEST OF KYUSHU

By
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It is already known that the floating seaweeds play a certain role for fishes in relation to their spawning or to their habitat of the youngs and juveniles. For example, pacific saury *(Cololabis saira)* and flying fishes lay their eggs on the floating seaweeds, and juveniles of several fishes such as yellowtail *(Seriola quinqueradiata)* grow in accompany with them. And in this connection, the floating seaweeds have been considered to have relations with fisheries of these fishes. However, our knowledge concerning the kind of seaweeds found afloat and their relationship with the fishes has been insufficient. Among the works already done more or less extensively on this subject there are those of PARR (1939) and KIMURA *et al.* (1958). The former work includes a taxonomic and quantitative studies on the floating seaweeds found in the western North Atlantic, and the latter was done with particular attention on the spawning of pacific saury.

Since March, 1957, the authors have taken part in the general programme of study on the floating seaweeds from the phycological view point. Main field for study has been the sea near Tsuyazaki, northern Kyushu, where the Fishery Research Laboratory of Kyushu University locates. Results of the investigations obtained are summarized as follows: (1) The floating seaweeds were found more often near the current rip lying near shore. (2) They were most abundant in quantity in May or June. (3) Species of *Sargassum* composing the floating seaweeds were nearly the same with those found growing on the shore around Tsuyazaki. (4) These species appear seasonally and dominant species alternated one after another, and this phenomenon can be explained from the fact that their growing and fruiting periods differ according to the species. From these results, it is assumed that almost all of the floating seaweeds found in the sea to the north of Kyushu came from the *Sargassum* vegetation growing on the shore along the coasts of northern Kyushu, but this does not exclude the possibility that small amount of them might have come from the sea of western Kyushu or more further southern parts. The basis of this argument lies in the respect that (1) almost all species of *Sargassum*

forming the floating seaweeds of northern Kyushu were identical with those collected along these coasts, and (2) only small quantities of the species belonging to the subgenus *Eusargassum* were met with in this district. However, this assumption will be confirmed after our knowledges on the floating seaweeds of the sea to the west and south of Kyushu are obtained to some extent. At the same time, more extensive information concerning the distiribution pattern of the floating seaweeds will come from the surveys on wider range of the area.

The authors carried out the surveys from the point of view above mentioned in April and June, 1959. Results are reported below and some considerations are made with reference to the distribution and species composition of the floating seaweeds.

Before going further, the authors express their thanks to Mr. SUGIYAMA in the Nagasaki Maritime Safety Office, Mr. MIYOSHI in the Hukue Maritime Safety Base, Mr. YOSHII, captain of the patrol boat "Kikuchi", Mr. HAYASHI, captain of the patrol boat "Murachidori" and their crews, and to Mr. YAZUMI of the Kumamoto Prefectural Fisheries Experimental Station for their kindness shown in the course of surveys. Cordial thanks are also due to Prof. K. UCHIDA at the Faculty of Agriculture, Kyushu University. Mr. FURUKAWA and Mr. MACHIDORI are kind enough to assist the surveys.

General Description of the Sea Condition off the Western Kyushu

Distribution pattern of the floating seaweeds found in the surveyed area must be considered in reference to the sea conditions. For this district, we already have at hand the Report on the Tusima Current Expedition (1958), which are summarized as follows:

The Tusima current branches off the main current of Kurosio at west of Amami-ôsima Island, and flows north passing by the west of Danzyo Islands to the west of Gotô Islands, then goes into Japan Sea through the Tusima straits. On the course to north, a side branch parts from the main current near Danzyo Islands flows to Gotô-nada, which lies between Kyushu and Gotô Islands. This branch takes a turn to the right in the Gotô-nada, changing its characteristics by mixing with coastal waters of western Kyushu, runs to south from Amakusa-nada heading to Kosiki Islands becoming a part of right turning eddy. This eddy is present all the year round at intermediate layer, and becomes stronger in winter. Movement of the surface water of Gotô-nada changes seasonally. Judging from the recovery stations of drift bottles, the surface water flows north in the season from April to July with the effect of southwest dominant wind, and turns to the right in other seasons. These currents are largely affected by the influence of the coastal water of the continent in the west and are also changed by the nature of the coastal waters of Kyushu.

Method

Methods of surveys were much the same to those employed in the surveys

at the sea between Tsuyazaki and Okino-sima Island of northern Kyushu (cf. SEGAWA *et al.* 1960). The number of floating seaweeds appearing on the sea surface of 10 m wide along the course of the boat was recorded every minute according to the weight grades of below 0.1 kg, 0.1–1 kg, 1–10 kg, 10–30 kg, 30–100 kg, and 100–300 kg.

The surveys were conducted along the lines shown in Table 1. The course shown as dotted lines in Fig. 2 was also surveyed, but these were not used here for the basis of consideration on the distribution of the floating seaweeds.

In order to know the distribution of the floating seaweeds, estimated weight of the weed observed every 10 minutes was calculated and shown on the figure as breadths of dark polygonals. Distance of 10 minutes differs according to the speeds of the ships concerned.

The reason for the choice of June when major part of the survey was done is that it is known from the previous surveys of the sea to the north of Kyushu that the floating seaweeds are found most abundantly in the season from May to June. At the same time, this season coincides with the growing period of juveniles and larvae of many fishes in accompany with the floating seaweeds, especially of yellowtail. Therefore the surveys in these months were needed.

Results and Considerations

1. Distribution of the floating seaweeds

As shown in Fig. 2, the floating seaweeds distribute more abundantly on near shore waters and on the sea around Gotô Islands, but less on far off shore area. When the sea condition of this area is taken into consideration, this means that the floating seaweeds are very infrequent in the area where the main stream of Tusima current or its major branches flow, and consequently rather simple in sea conditions and topography. In fact, on these areas, no large floating seaweeds of more than 2 or 3 kg were observed and only small fragment of weeds less than 0.1 kg in weight was rarely found afloat. On the contrary, large quantities of the floating seaweeds are met with in the area with complicated sea condition where eddies and countercurrents occur frequently, especially near the conflicting current rips along the coasts.

These distributional tendencies can be explained by the fact that the floating seaweeds were aggregated along the current ripes which lie near the coast, besides those rips are in short distance from the *Sargassum* vegetation.

Comparing the results obtained from the surveys conducted in April with those in June, there was slight difference in distribution of the floating seaweeds. But the quantity of the floating seaweeds was far less in April than in June. This is caused from the growth cycle of *Sargassum* growing on the shore of these districts. Most species of *Sargassum* mature in late spring or in early summer (cf. SEGAWA *et al.* 1959).

Concerning the Ariake Kai, major part of the floating weeds were of *Zostera*, and floating *Sargassum* was rarely seen on the survey courses figured

with dotted lines in Fig. 2. Floating *Zostera* leaves are frequently observed not only in Ariake Kai, but also in Hakata Bay and other shallow bays where rocky shore is rather scanty.

2. Species of Sargassum constituting the floating seaweeds

Only a few opportunities to collect the floating seaweeds occurred in these surveys. Therefore, the seasonal changes in relative abundance of each species of *Sargassum* were dimly known. The floating seaweeds were collected once in April and in June on the sea to the southeast of Hukue Island. The list of species and relative abundance of each species are given in Table 2. The floating seaweeds collected in April were composed chiefly of *S. serratifolium*, *S. patens* and *S. tortile*, and the species belonging to *Eusargassum* formed very small proportions. On the other hand, of those collected in June, *Eusargassum* species occupied more than 30% in weight. This was true not only in the material from the south of Hukue Island, but also confirmed by the observations made at every part of Gotô-nada while the survey boats were sailing. The species of *Eusargassum* are recognized from the respect that they are yellower and paler in colour than the other species. Considerable quantities of *Eusargassum* species were obtained from the survey on the materials washed ashore at several places around Gotô Islands (i. e., south coast of Hukue Island, Uku Island and Ikituki Island, etc.). Although several species of *Eusargassum* were collected during the survey of the floating seaweeds found in Gotô-nada, these have not been identified as to species. The stations where these *Eusargassum* species were confirmed to grow according to the authors' observation are shown in Fig. 1. These stations are considered to be northern limits of these species which grow abundantly on more southern coasts. The floating seaweeds found in Gotô-nada might be derived from the *Sargassum* vegetation present along the coasts around this area. Most species of *Eusargassum* mature in summer. Therefore, it is natural that they appear more abundantly in June than in April. On the other hand, species belonging to *Eusargassum* appeared in the floating seaweeds composing only a small amount on the coastal waters of northern Kyushu. They did not exceed 2% of the weight even in July when they were most frequently present.

According to the survey performed by the Kumamoto Prefectural Fisheries Experimental Station, drift bottles thrown in Gotô-nada in June or July were carried to north and entered into Iki Passage or Tusima East Passage. It is highly probable when consulting this result that the floating seaweeds drift from Gotô-nada to Genkai-nada, though they may be very small quantities judging from the comparison of the *Sargassum* flora of both areas.

Summary

The floating seaweeds found on the sea to the west of Kyushu were investigated in April and June, 1959. For this purpose, 13 survey lines were chosen. The following results were obtained:

1. The floating seaweeds were found more abundantly near shore waters

of Kyushu and Gotô Islands, and less in off shore area. This is the same as found in the sea to north of Kyushu.

2. In this district, the areas where the floating seaweeds distributed abundantly had complicated sea conditions caused from the eddies or counter-currents and current rips.

3. Very small quantities of the floating seaweeds occurred in the main streams of Tusima current or its branches.

4. On the sea to the west of Kyushu, the floating seaweeds were found abundantly in June, compared with those in April.

5. In June, the floating seaweeds observed at the current rips of Ariake Kai were chiefly composed of *Zostera*. This is the case usually met with in the bays.

6. In this district, while the relative abundance of the species forming the floating seaweeds was much similar in April with those that found in the northern coast of Kyushu, it differed in that large proportions of weeds occupied by the species of *Eusargassum* in June.

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Fig. 1. General scheme of the sea condition and geographical distribution of *Eusargassum*. Open circles show the absence of *Eusargassum* and solid ones the presence of *Eusargassum*.

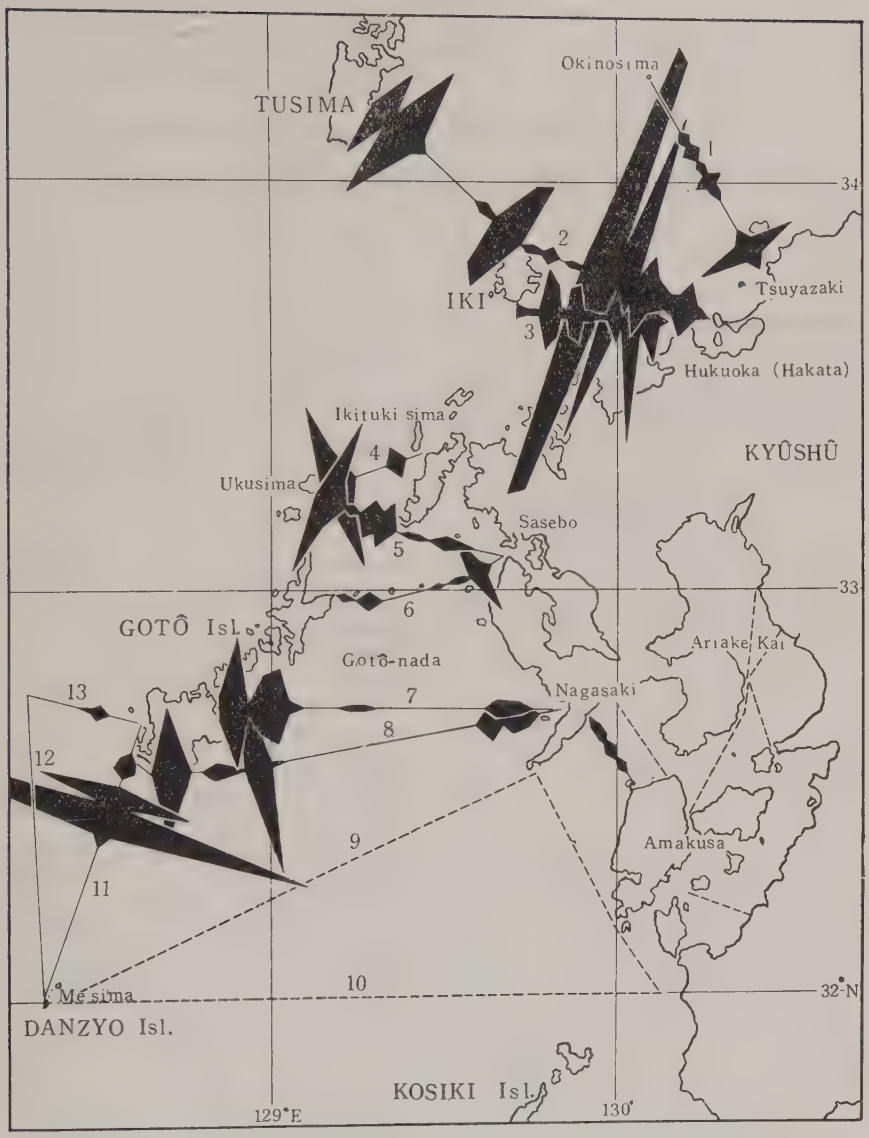

Fig. 2. Survey courses and distribution of the floating seaweeds

Table 1.

	Course Line	Distance	Name of boat	Date	Observer
1.	Tsuyazaki–Okino sima Isl.	60 km	Wakasugi	June, 19, '60	Sawada. Yoshida
2.	Hakata–Katumoto–Izuhara	95	Taisyû maru Isyû maru	„ 7, 9	Segawa, Kamura
3.	Hakata–Gô no ura	50	Taisyû maru	„ 7	„
4.	Ikituki Isl.–Uku Isl.	30	Taiko maru	„ 8	Higaki
5.	Sasebo–Uku Isl.	55	Namizi maru	„ 7	„
6.	Sasebo–Arikawa	50	„	„ 6	Sawada
7.	Nagasaki–Hukue	90	Kaéde maru	„ 6	Yoshida
8.	Nagasaki–Ose saki	115	Huji maru	„ 13	„
9.	Nomo saki–Me sima Isl.	140	Aso	„ 13	Machidori
10.	Akune–Me sima Isl.	165	„	„ 12	„
11.	Tamano ura–Me sima Isl.	70	Muratidori	„ 12	Yoshida, Furukawa
12.	128°17'E, 32°46'N–Me sima Isl.	85	„	„ 12	„
13.	Tamanoura–128°17'E, 32°46'N	30	„	„ 12	„
	Omuta–Simabara	30	Syôkin maru	„ 21	Segawa
	Nagasu–Simabara	15	Syôzyu maru	„ 22	„
	Misumi–Simabara	20	Hatuhime maru	„ 21	„
	Hondo–Simabara	40	Sirakiku maru	„ 22	„
	Aba–Oniike	30	Keizan maru	„ 21	„
	Mogi–Tomioka	25	Nagisa maru	„ 22	„
	Minamata–Usibuka	40	Hagoromo maru	July, 5	Yoshida
1.	Tsuyazaki–Okino sima Isl.	60	Wakasugi	Apr. 15	Sawada, Yoshida
2.	Hakata–Katumoto	95	Taisyû maru	„ 20	Higaki, Yoshida
7.	Nagasaki–Hukue	90	Kaéde maru	„ 23	Segawa, Yoshida
11.	Tamano ura–Me sima Isl.	70	Kikuti	„ 25	„

Table 2. Relative abundance by weight of the species of floating seaweeds

Species	Apr. 26, '60	June 13, '60
S. serratifolium	57.7 %	+
S. patens	19.2	39.5 %
S. tortile	11.5	
S. piluliferum	3.8	26.3
S. horneri	3.8	
S. hemiphyllum	1.9	0.9
S. ringgoldianum	+	
S. thunbergii		0.9
S. (Eusargassum) spp.	+	32.4

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in Japan (Special Number 5)
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ON THE SPECIES OF THE LAVER, *PORPHYRA*, AT CULTURE GROUNDS IN THE ARIAKE SEA

By

Seiji Migita

(Faculty of Fisheries, Nagasaki University)

It is well known that the species of cultivated laver is mainly *P. tenera* and sometimes it grows with another species in Japan. It has been reported that a few investigators[1-5] who studied in the *P. tenera* have tried to separate it into several forms.

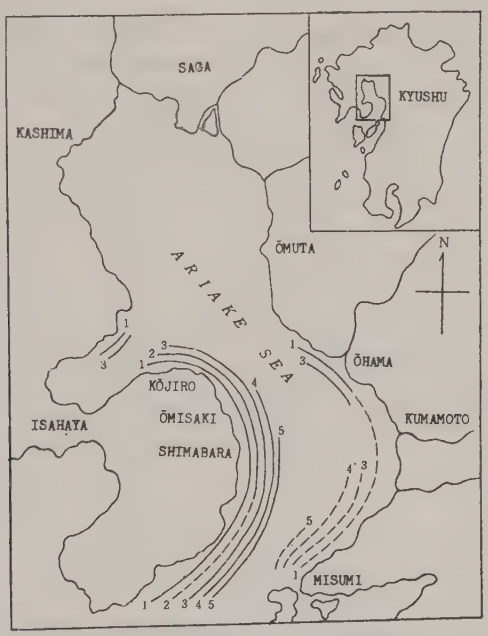

Fig. 1. A map of the Ariake Sea, showing the distribution of the species of *Porphyra*
1: *P. tenera type A*, 2: *type B*, 3: *P. kuniedai*, 4: *P. seriata*, 5: *P. suborbiculata f. latifolia*

For some years, the writer has made a morphological study on the species of cultivated *Porphyra* in the Ariake Sea, and in conjunction with the same study, the geographical distribution and ecological observation of them were also made.

The writer wishes to express his sincere thanks to the late Professor S. Segawa of Kyushu University for his invaluable advice and encouragement.

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	Misumi–Simabara	20	Hatuhime maru	„ 21	„
	Hondo–Simabara	40	Sirakiku maru	„ 22	„
	Aba–Oniike	30	Keizan maru	„ 21	„
	Mogi–Tomioka	25	Nagisa maru	„ 22	„
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S. thunbergii		0.9
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Seiji Migita

(Faculty of Fisheries, Nagasaki University)

It is well known that the species of cultivated laver is mainly *P. tenera* and sometimes it grows with another species in Japan. It has been reported that a few investigators[1-5] who studied in the *P. tenera* have tried to separate it into several forms.

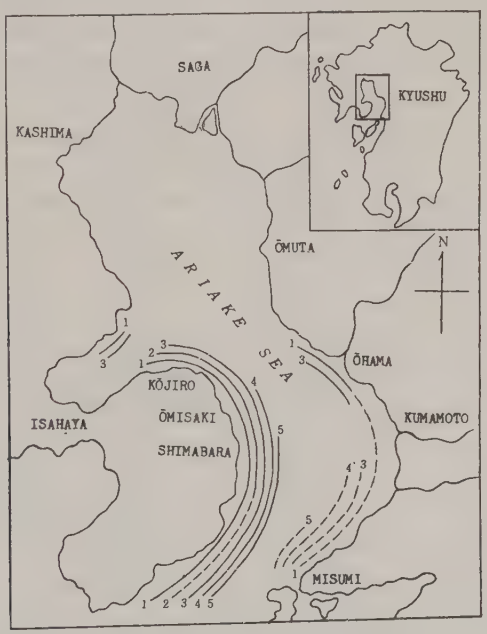

Fig. 1. A map of the Ariake Sea, showing the distribution of the species of *Porphyra*
1: *P. tenera type A*, 2: *type B*, 3: *P. kuniedai*, 4: *P. seriata*,
5: *P. suborbiculata f. latifolia*

For some years, the writer has made a morphological study on the species of cultivated *Porphyra* in the Ariake Sea, and in conjunction with the same study, the geographical distribution and ecological observation of them were also made.

The writer wishes to express his sincere thanks to the late Professor S. Segawa of Kyushu University for his invaluable advice and encouragement.

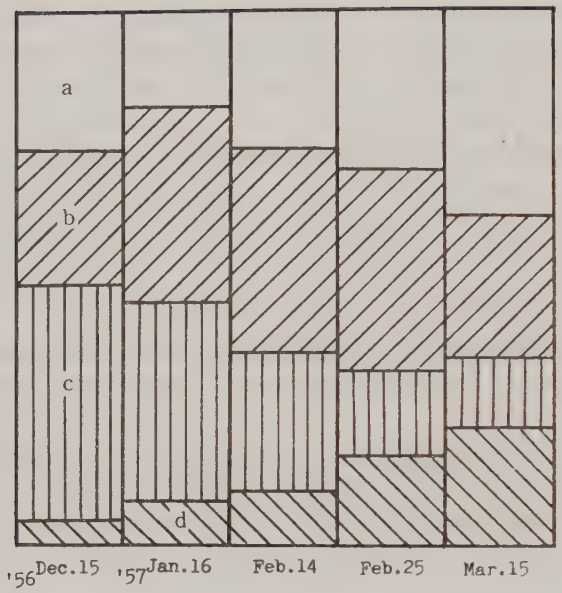

Fig. 2. Seasonal variation of the species of *Porphyra* on laver-nets at Ōmisaki
a: *P. kuniedai*, b: *P. tenera type A*, c: *type B*, d: *P. seriata*

P. suborbiculata Kjellman *f. latifolia* Tanaka

Japanese name; Hiroha-maruba-amanori.

Frond ovate or reniform, membranaceous, monostromatic, with slightly undulated margin, microscopic spinulate at the marginal portion, 5–10 cm broad, colour purple red, 22–35 μ thick.

This thalli grow on rocks and laver-nets from October to July and grow plentifully during February–May. Some fronds of this species always liberate monospores developing into a bud of thallus. Therefore, the "summer thalli" survive until the beginning of August. The "summer thalli" are found more in quantity than that of *P. kuniedai* along the coast of the Shimabara Peninsula.

The distribution of aforementioned Porphyra was shown in Fig. 1. In general, the thalli of *P. tenera* and *P. kuniedai* grow well in the inland sea where salinity is lower than normal sea water, while *P. suborbiculata f. latifolia* and *P. seriata* grow better at the open coasts. In the eastern coast of the Shimabara Peninsula where those *Porphyra* are cultivated together, the seasonal increase of the thalli of *P. kuniedai* and *P. seriata* is observed during the months of February and March.

Annual variations of these species at Shimabara and Ômisaki were shown in Fig. 3. When the culture of *Porphyra* is continued for several years in such localities, the thalli of *P. tenera* is deemed to increase in quantity to some degree.

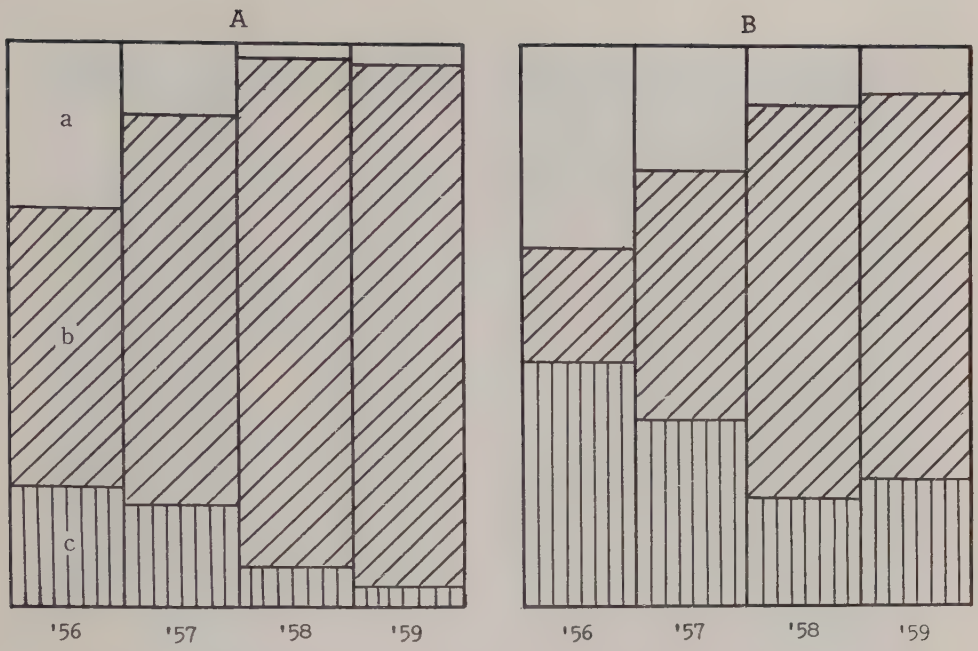

Fig. 3. Annual variation of the species of *Porphyra* on laver-nets setting the early in October at Shimabara (A) and Ômisaki (B)
a: *P. kuniedai*, b: *P. tenera type A*, c: *type B*

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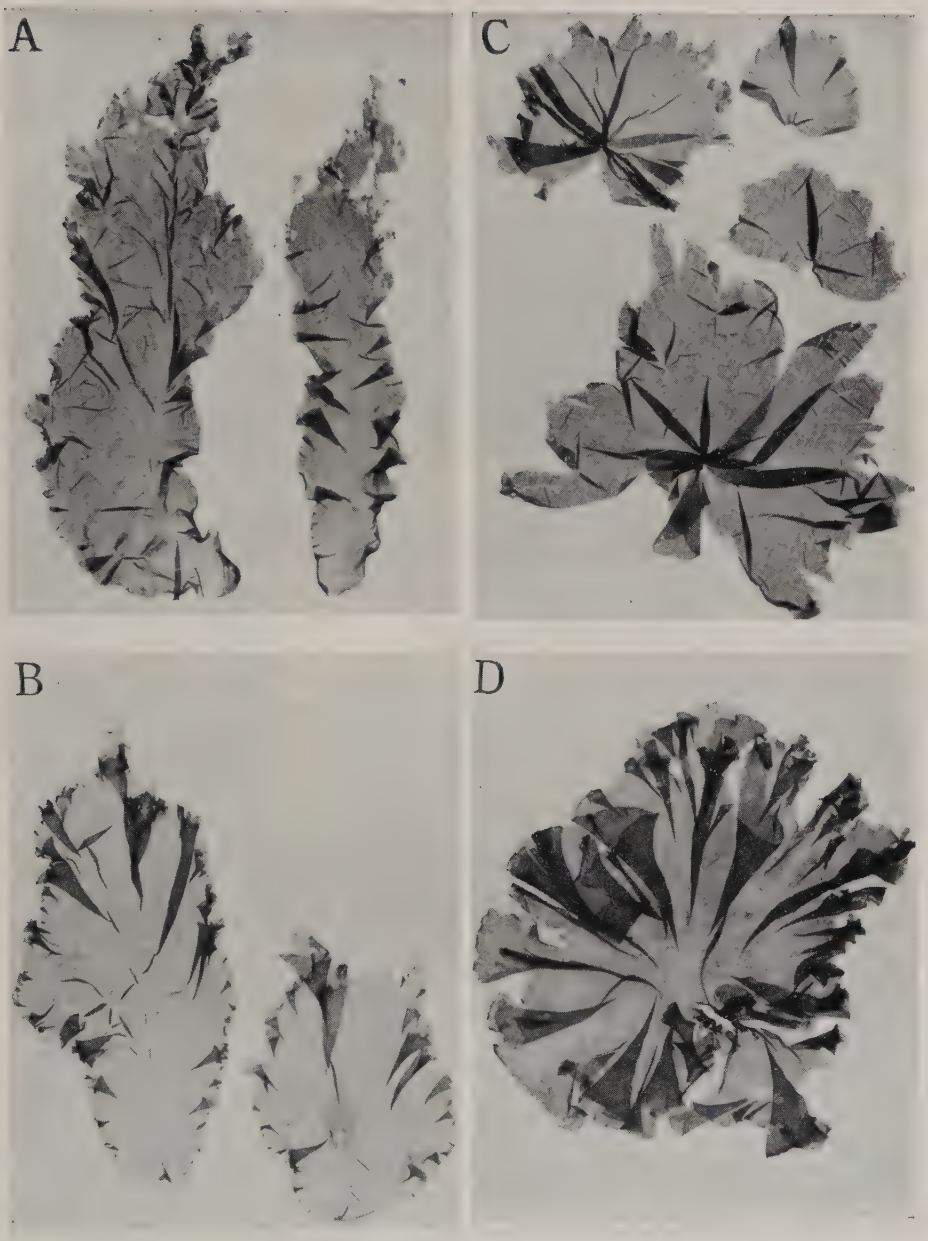
Explanation of Plates

Plate I. A: *P. tenera* Kjellman *type A*, ×2/5.
B: ———— *type B*, ×1/2.
C: *P. kuniedai* Kurogi, ×1/3.
D: *P. seriata* Kjellman, ×1/4.

Plate II. E: *P. suborbiculata* Kjellman *f. latifolia* Tanaka, ×1/2.
F: Buds of each species. a; *P. tenera type A*, b; *type B*, c; *P. kuniedai*, d; *P. seriata*. ×1/2.
G: Sporelings of *P. tenera type A*, ×170.
H: ———— *P. tenera type B*, ×135.
I: ———— *P. kuniedai*, ×135.
J: ———— *P. suborbiculata f. latifolia*, ×60.


A
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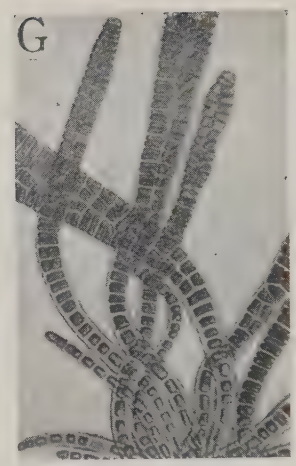
D

E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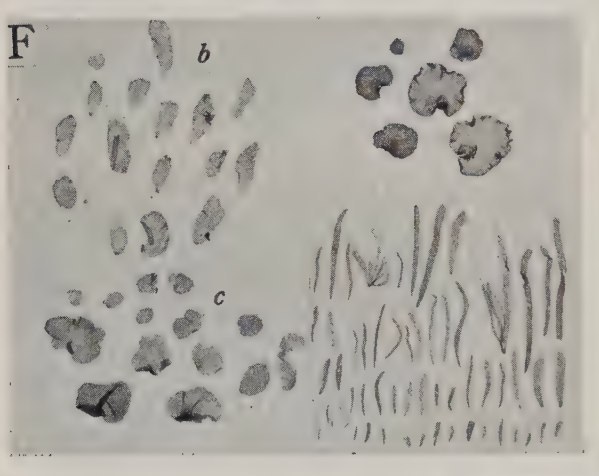
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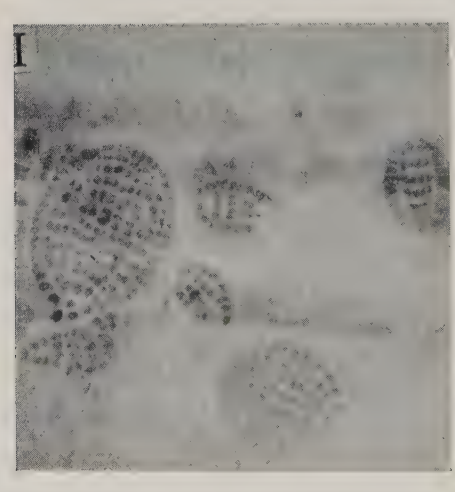
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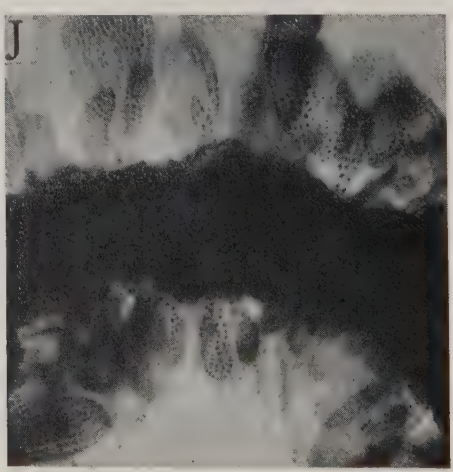
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March 1961

THE CHARACTERISTIC ASPECTS OF THE MOLLUSCAN FAUNA IN THE WEST COAST OF KYUSHU, JAPAN

By

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There are many large bays, such as Omura, Chijiwa, Ariake and Yatsushiro, bordered from the Sea of East China by Nishisonogi, Nomo and Shimabara Peninsulas and the Islands of Amakusa on the West coast of Kyushu along which the Tsushima Current, a branch of the warm current, Kuroshio, sets to the north.

1. Thus the molluscan fauna of this coast consists of two elements, one of which is the warm current element ranging from the tropic sea of the Pacific to north up to Japan and another is the continental coast element which is characterized in distributing in the bays of Japan as well as the continental coast of South-east Asia and had been more widely distributed in Japan in the prehistoric age than at present. No species of the cold current element is found.

2. The warm current weakly influences on the West coast of Kyushu rather than the Pacific coast of Japan, so that the tropic molluscan species, namely cowries and cones, rapidly decrease in number in the West coast of Kyushu as well as in the coast of Japan Sea, both of which are washed by the Tsushima warm current, as shown in the Table I.

Moreover, in some species the specimens found in both the coast of Japan Sea and the Pacific are divided into subspecies which are differrent from each other. For example, *Tegula (Omphalius) pfeifferi pfeifferi* (Philippi) is collected from the Pacific coast and *T. (O.) pfeifferi carpenteri* (Dunker) from the West coast of Kyushu and the Japan Sea coast. Therefore the molluscan fauna of this coast is close to that of the Japan Sea coast rather than that of the Pacific coast.

3. The species belonging to the continental coast element are historically the decendants of the fauna of Pleistocene, the period in which the islands of Japan were more closely connected with the Asiatic continent than at present. Therefore many species of the continental coast of Asia had been widely extended their ranges in Japan in that period. But they gradually restricted their distributions and lost their comfortable niches as Japan was isolating from the continent of Asia. At present some of them are only found in some bays, such as, Ariake,

Table I.

	Locality	Number of species	
		Cowries	Cones
	Formosa (Taiwan)	49	55
	Ryukyu Islands	64	78
	Amami Islands	48	50
Pacific coast	Miyazaki Pref., Kyushu	33	22
	Kochi Pref., Shikoku	42	51
	Shionomisaki, Wakayama Pref., Honshu	41	41
	Sagami Bay, Honshu	30	10
West coast of Kyushu and Japan Sea coast *	Amakusa, Kumamoto Pref., Kyushu *	16	3
	Fukuoka Pref., Kyushu	15	8
	Yamaguchi Pref., Honshu	14	4
	Fukui Pref., Honshu	8	1

Bay, Inland Sea of Japan, Ise and Tokyo Bays of Japan as the relics.

The following are the characteristic relic species of the continental coast element in the West coast of Kyushu, which are chiefly found in Ariake Bay.

a. *Anadara (Tegillarca) granosa* (Linné)
Ariake Bay; Tomioka, Amakusa; Inland Sea of Japan; Mikawa and Ise Bays. Osaka (semifossil); Tokyo (semifossil in shell mounds) and Sendai (semifossil in shell mounds); Nanao (semifossil).

b. *Trisidos tortuosa kiyonoi* (Makiyama)
North coast of Kyushu; Inland Sea of Japan (Yamaguchi Pref.); Mikawa Bay. Nagasaki (semifossil); Osaka and Sakai (semifossil); Toyohashi (semifossil).

c. *Striarca (Estellarca) olicacea* (Reeve)
Ariake Bay; Inland Sea of Japan (Kojima Bay) and Tokyo Bay.

d. *Standella pellucida* (Gmelin)
Ariake Bay; Inland Sea of Japan (Kojima Bay). Nagasaki (semifossil); Osaka (semifossil) and Hekinan, Aichi Pref. (semifossil).

e. *Glauconome chinensis* Gray
Ariake Bay; Inland Sea of Japan (Kojima Bay) and Tokyo Bay.

f. *Sinonovacula constricta* (Lamarck)
Ariake Bay and Inland Sea of Japan (Kojima Bay); Mikawa Bay (introduced).

g. *Potamocorbula amurensis* (Schrenck)
Tomioka, Amakusa (dead specimens only); Harima Nada, the east part of the Inland Sea of Japan (dead specimens only); Mutsu Bay and Takahoko-numa, Aomori Pref. and Hokkaido. Naruto Channel between Shikoku and Awaji (fossil); Nishinomiya near Osaka (semifossil); Tokyo and its environs (fossil).

h. *Assiminea (Pseudomphala) latericea miyazakii* Habe
Ariake Bay.

i. *Cerithidea largillierti* (Philippi)
Ariake Bay; Omura Bay; Inland Sea of Japan and Tokyo Bay.

j. *Cerithidea ornata* A. Adams
Ariake Bay; Inland Sea of Japan (Kojima Bay).

k. *Tectonatica tigrina* [Roeding]
Tomioka, Amakusa; Ariake Bay; Inland Sea of Japan.

l. *Lunatia fortunei* (Reeve)
Ariake Bay.

m. *Ceratostoma rorifluum* (A. Adams et Reeve)
West and north coasts of Kyushu.

n. *Zeuxis succinctus* (A. Adams)
Ariake Bay; Omura Bay and Inland Sea of Japan. Osaka (semifossil)

o. *Varicinassa varicifera* (A. Adams)
Ariake Bay; Chijiwa Bay; Inland Sea of Japan.

p. *Salinator takii* Kuroda
Ariake Bay

q. *Ellobium chinense* (Pfeiffer)
Ariake Bay; Inland Sea of Japan; Ise Bay and Tokyo Bay.

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AN ECOLOGICAL STUDY OF THE BRACHYURAN COMMUNITY ON TOMIOKA BAY, AMAKUSA, KYUSHU

By
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The main object of this study is the quantitative representation of the distribution of benthic animals with special reference to the brachyuran group by an accurate comparing method, and to clarify the correlations between the species distribution and the environmental gradients.

Procedures

The survey was carried out in Tomioka Bay in the north-most part of

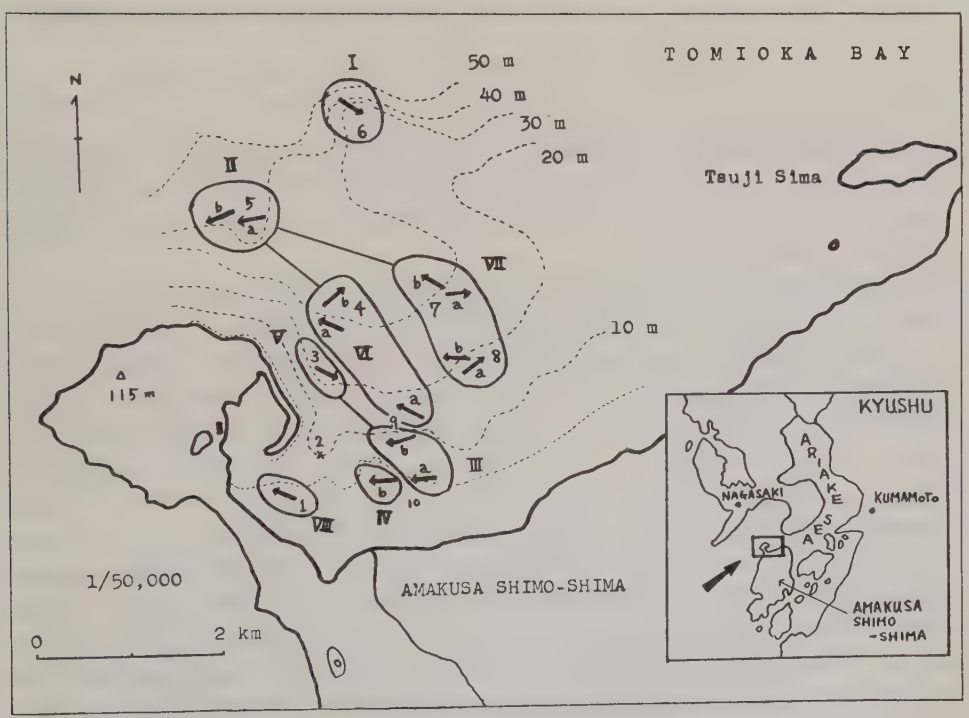

Fig. 1. The map of the sampling area, sampling station, and the arrangement of groups of species composition. Arrows in the map show the course of dredging and the figures a and b are the first and second dredging.

Table 1. Depth of water, water temperature and the substratum of the sampling station. Survey was carried out on 10th, 11th September, 1959

St.	Depth (m)	Bottom Water temp.	% weight of shell	Outline of Substratum
1	4	27°C	13.8	Lower margin of the *Zostera* zone, fine fixed sand and mud.
3	21–22	26.2°C	48.0	Sand mixed with the stone of various size
4–a	29	25°C	39.0	Coarse sand
4–b	32	25.7°C	27.0	„
5–a	37	25.6°C	75.8	Coarse shelly sand, on the course of the current
5–b	42	25.6°C	67.0	„
6	35	25.6°C	42.0	Coarse sand mixed with large shell remains.
7–a	29.5	25.3°C	32.0	Fine sand (silty)
7–b	31	31°C	45.0	Relatively fixed fine sand
8–a	17	26°C	46.0	Fine sand
8–b	17	25.6°C	53.0	„
9–a	10.5	?	70.0	Fine shelly sand mixed with the many sort of debris.
9–b	11	26.5°C	85.0	Coarse shelly sand and large shell remains
10–a	7	27°C	78.0	Coarse shelly sand, detritus of *Zostera marina*.
10–b	7	27·3°C	?	Fine sand mixed with the gravels.

Amakusa Island, Kyushu. This bay is situated at the entrance of Ariake inner-sea and faces on East China Sea with its western side. For its widely opened entrance and shallowness, Tomioka Bay may rather be called a coastal shallow shelf than a bay (Fig. 1).

The samples were collected on 10th and 11th, September, and 25th, December, 1959 at ten sampling stations set in pairs along five contour lines of depth in this bay. The samplings were made twice at one station by three minutes hauling of a simple-type dredge (76×36 cm in width, 150 cm in depth and made of the net of 2 sq. mm.). At the same time, the collection of substrata-sample were carried out by the Birge Ekman grab. Some hydrographic conditions such as the depth and temperature of benthic water at the sampling stations are shown with the description of substrata in Table 1. Collected specimens were reserved at first in 5% hormaline and later in 70% alcohol. The samples of substrata were dried at 100°C for 24 hrs. To solute the shell debris in the samples, 10 grams of each was treated with N/5-HCl aq. and filtered. The residue was dried also at 100°C for 24 hrs. and weighed. The rest of the samples was sieved with standard sieves and weight percentage of soil grain of each size (mm.) was calculated.*

* The samplings of substrata on st. 1 and 9-a were failed.

Results and Discussion

1. Grouping by species composition

(1) Species-abundance table

Among twenty samples from ten stations, three samples were omitted for the failures of sampling (Sts. 2, 6-b and 1-b) and two were summed up for its scarcity of specimens (Sts. 3-a and b). The list of species and numbers of specimen of fifteen samples are shown in Table 2. By the samplings in September, 1134 brachyuran specimens belonging to 38 species of 10 families were collected. The total number of specimens including those of December was 1241 belonging to 42 species, 12 families.

(2) Method for grouping

For the grouping of samples with similar species compositions, Morisita's index for measuring the similarity between communities was used. This index is calculated as follows: Letting n_{1i} and n_{2i} be the numbers of specimen of i-th species occurring in 1st and 2nd samples, and N_1 and N_2 be the total numbers of specimens of each sample, and putting

$$\lambda = \sum_{i=1}^{\infty} n_i (n_i - 1) / N (N - 1),$$

then the index value is obtained as

$$C_\lambda = 2 \sum_{i=1}^{\infty} n_{1i} \; n_{2i} / (\lambda_1 + \lambda_2) N_1 \; N_2.$$

The value of C_λ will be about 1 when the two samples belong to the same community and will be zero when no common species is found between them. Since this index is not influenced by the sample size, it seems to be most adequate for grouping of species associations.

(3) Grouping

The results of application of Morisita's index to the data of Table 2 are shown in Table 3. According to the degrees of similarity among samples, eight groups of species composition are recognized, as is shown in Figure 2 or in the first column of Table 3. The distribution of the groups in the bay is shown in Figure 1, suggesting several zonal arrangements of the groups from northeast to southwest.

(4) Divergence of species

Some mathematical formulae representing the relationship between the number of species and the number of specimens in a community has been developed by several workers (Motomura, '32, Brian, '53, Preston, '48, MacArthur, '57, etc.). Williams ('43, '47) has suggested that Fisher's logarithmic series (Fisher, et al '43) is applicable to the relationship and has designated a constant α, to represent the index of diversity of species in a community.

However, it seems to be more suitable to use $1/\lambda$, instead of α, as an index of diversity for the present study, because the λ described in the previous section is uninfluenced by the sample size whether the species-individual relation

Table 2. The species list and the numbers of individuals in the samples

Species	Sampled on 10th and 11th, September, 1959																Sampled on 25th, December, 1959			
	1	3	4–a	4–b	5–a	5–b	6	7–a	7–b	8–a	8–b	9–a	9–b	10–a	10–b	Total	3	7	9	Total
Dorippe dorsipes		1			2	2	1	1								7			1	1
D. granulata			5		5	20	4		1	2	1	3				41		1		1
Calappa lophos																0			1	1
Ebalia sp.								1								1				
Oreophorus rugosus			2		3											5		1	3	4
Nursia elegans japonica			16	1	41	53	7			4	4	7	2			135			6	6
Arcania undecimspinosa											2					2				
A. globata			4		6	21	6	2	2	4	9	3	2			59				
Myra fugax		1	1								1	1				4				
Cryptocnemus pentagonus					2	2							1			5	1			1
Leucosia longifrons		1	8	1	13	14			2	5	3	1	1			49	1		2	3
L. haematosticta			4		6	3		5	3	9	15	3	1			49	1	9	11	21
Philyra platycheira															5	5				
Trigonoplax unguiformis					1								2			3			1	1
Paratymolus pubescens	1		4		2		1			6	5	1	2	2	1	25	1		2	3
Achaeus spinifrons													1			1				
A. tuberculatus		1	12		11	7				2	3	4				40			3	3
A. sp.						1						1				2				
Pugettia incisa			15		14	8	4	1		5	5	9	12	12		85			2	2

Species	Sampled on 10th and 11th, September, 1959																Sampled on 25th, December, 1959			
	1	3	4–a	4–b	5–a	5–b	6	7–a	7–b	8–a	8–b	9–a	9–b	10–a	10–b	Total	3	7	9	Total
P. quadridens															4	4				
Hyastenus diacanthus																0			1	1
Micippa thalia			2			12					2	1		1		18				
Lambrus validus			1		3			1		7	2		2	3		19	1		1	2
Gomeza distincta																0		1		1
Portunus gladiator		1	2	2	4					3	1	1				14				
P. hastatoides												3			1	4		2		2
P. sp. (subad.)															1	1				
Charybdis variegata			2	1	14	24	4	1	2	1		3	2	1		55		3	2	5
Thalamita sima	8	1											3			12				
Kraussia nitida						1										1				
Cycloxanthops lineatus					1	3	1									5				
Xantho distinguendus	1	2													2	5				
Actaea polyacantha								2				1		2		5				
Actaea savignyi																0			1	1
Actumnus squamosus		3	25			16	3	9	3	7	14	8	24	8		120	4	4	6	14
Pilumnus minutus		23	19		15	4	1				1	14	13	5	6	101	3		2	5
Calmania prima		1	17	1	32	17	5	11	3	17	11	16		1		132	6	14	7	27
Carpoporus orientalis												1				1				
Heteroplax nitida					5	11	88									104				
H. nagasakiensis							1									1				
Typhlocarcinus vilosus																0		1		1
Hemigrapsus longitarsis	13															13				
Macrophthalmus telescopics															1	1				
Total (N)	23	35	139	6	180	219	126	34	16	72	79	81	68	35	21	1134	19	36	52	107

Table 3. Values of the index of community similarity (C_λ) calculated from the Table 1

Group	No.	SAMPLE NUMBER											
		5–a	5–b	9–b	10–a	10–b	3	4	9–a	7–a	7–b	8–a	8–b	1
I	6	.176	.210	.058	.059	.008	.018	.080	.098	.072	.080	.698	.248	0
II	5–a		.780	.194	.293	.163	.235	.668	.734	.425	.524	.590	.470	.002
	5–b			.339	.265	.040	.088	.725	.640	.391	.675	.508	.508	0
III	9–b				.940	.222	.489	.830	.646	.562	.543	.375	.581	.004
	10–a					.267	.364	.785	.671	.475	.367	.429	.493	.008
IV	10–b						.670	.333	.413	0	0	0	.482	.008
V	3							.467	.602	.098	.091	.072	.180	.004
VI	4								1.035	.495	.804	.716	.817	.006
	9–a									.472	.763	.720	.670	.002
VII	7–a										1.052	.835	.850	0
	7–b											.931	1.032	0
	8–a												.626	.014
	8–b													.012
VIII	1													—
	λ	.145	.108	.118	.182	.153	.404	.090	.098	.183	.100	.122	.122	.400

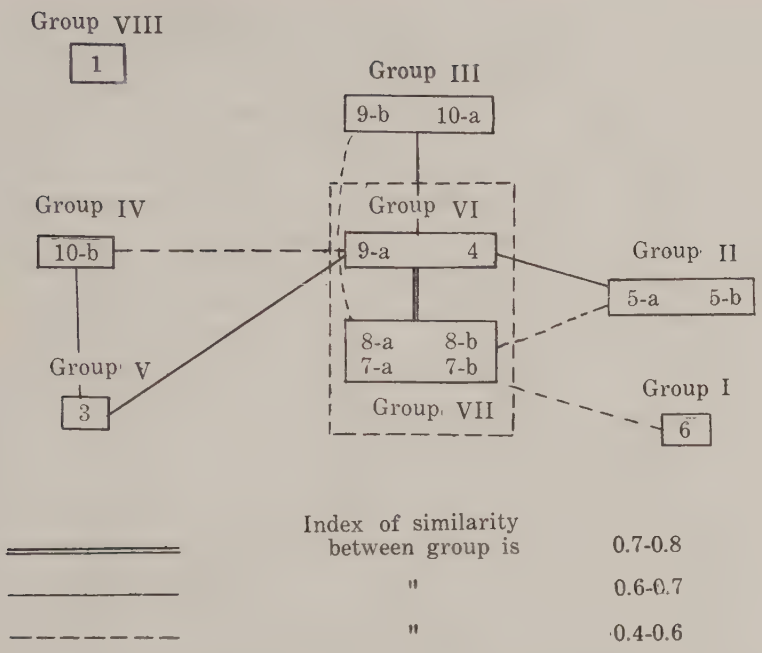

Fig. 2. Figure of the groups of species-composition

follows a logarithmic series or not. In the case of logarithmic series, it has been proved that $1/\lambda = \alpha + 1$. The values of $1/\lambda$ were 2.02 for group I, 7.88 for II, 6.68 for III, 6.53 for IV, 2.48 for V, 10.64 for VI, 7.59 for VII and 2.50 for VIII. It may be noticed that the $1/\lambda$ values of the groups II~VII excepting V, are much larger than those of the deep area group (I) and the littoral group (VIII), representing the ecotonial character in most parts of this bay.

(5) Habitat conditions and species groups

Depth: It is difficult to find a direct relationship between the depths and the species groups, but the samall C_λ values between group I or VIII and other groups as well as the small $1/\lambda$ values of I and VIII may indicate the effects of depth at least to some extent (cf. Table 1).

Shells: The percentage weight of shells in each sample is shown in Table 1. The amounts of shells are largest in groups II and III and smallest in group VIII (intertidal), but are not much different among the other five groups.

Texture of the substrata: The accumulation curves of weight percentages of soil grains are shown in Figure 3. It is clear that the shapes of curves belonging to one species group are resemble each other but the shapes of different group are considerably different. For example, much resemblances are seen between the curves of 5-a and 5-b in group II, between 10-a and 9-b in group III, and between 7 and 8 in group VII, while the differences of the curve are clear among the groups, though an exception is seen between group V and VI.

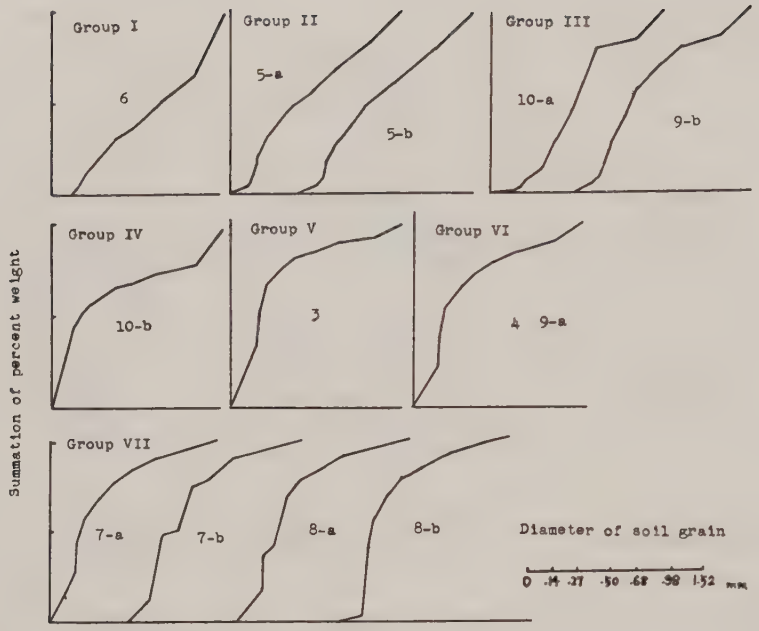

Fig. 3. The soil grain distribution of substrata on the sample stations

Coarse sand and plenty of large shells in groups I, II and III seem to be due to the strong current close to the bottom as described by Jones ('52). And so, it becomes plausible that the tidal currents affect on the association of species through the cleaning effect of the finer particles.

2. Abundance and distribution of each species and species groups

(1) Graphic illustration of abundance and frequency of each species

Taking the frequency of appearance (%) of each species in the fifteen samples on ordinate, and the mean number of specimen of each species per sample in which each appeared on abscissa, each species is plotted in a graph (Fig. 4).

In this figure the mean values of frequency and abundance and their fiducial limits (95%) are also shown. By the mean value lines, this graph is divided into four areas. The species plotted on the area I are abundant and appear frequently. Then, this area may be called as "dominant area". In the same way, the area II may be called "exclusive" or "characteristic area", for the species on this area are abundant but appear infrequently. The area III may be "occassional area", for the species are scarce both in number and frequency. The area IV may be "common area", for the species uniformly appear for all samples but poor in numbers.

On the grouping of species composition, the species on "dominant area" may characterize the large community while the species on "characteristic area" characterize the small community. Two characteristic species, *Hemigrapsus longitarsis* and *Heteroplax nitida* bring marked dissimiarity of groups VIII

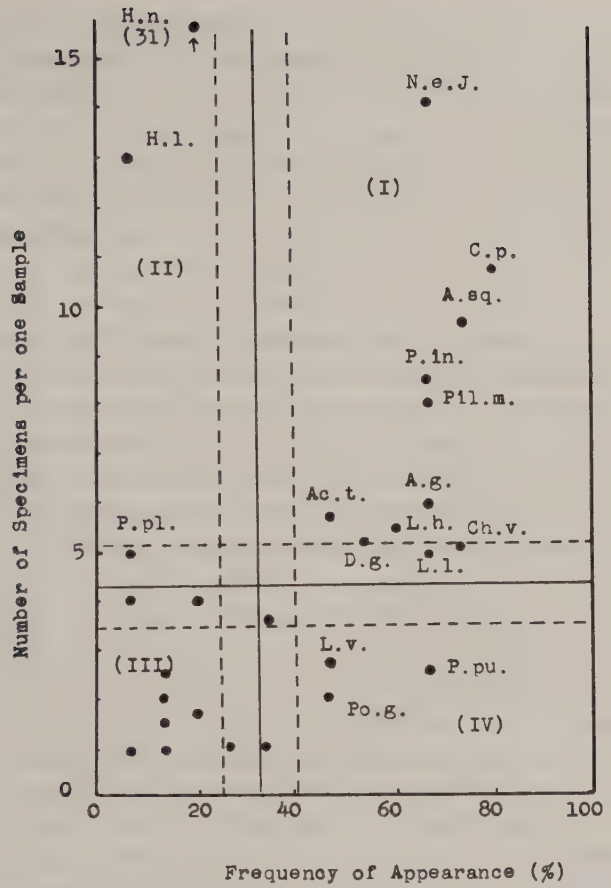

Fig. 4. Quadrant graph of the abundance and frequency of the species

and I against other groups. The former is a species exclusively found on the lower intertidal zone while the latter is found only in the outer part of the bay and seems to be a species of open sea.

(2) Interspecific correlations among dominant species:

The eleven species found on the "dominant area" are composed of three species of Xanthid crabs, four of Leucosiid, three of Majid, one of Dorripid and Portunid. To measure the interspecific correlation among these species, Morisita's index R_δ was used. His index (R_δ) between species X and Y is described as follows.

Setting,
$$\delta = \sum_{i=1}^{q} n_i (n_i - 1) / N (N - 1),$$

$$C_\delta = 2 \sum_{i=1}^{q} n_{xi}\ n_{yi} / (\delta_x + \delta_y)\ N_x\ N_y,$$

where n_i is the number of specimens of a species in the i-th sample and N is the total number of specimens of a species. Then,

$$R'_\delta = C_\delta - W_\delta, \qquad W_\delta = 2 / (\delta_x + \delta_y)\ q,$$

q is the number of samples, and $R_\delta = R'_\delta$ when $R'_\delta \geqq 0$, or $R_\delta = R'_\delta / W_\delta$ when $R_\delta' < O$. The value of R_δ will be $+1$ when the all samples are containing two species with equal density relations and be -1 when no sample of joint occurrence of the two species is found.

In the table 4, the results of calulations of this index on the eleven dominant species are shown. From these results, positively correlated species could be grouped as *N. e. japonica—D. granulata—Ar. globata—L. longifrons—C. variegata* group, *Car. prima—Ach. tuberculatus* group, and one species group of each, *Act. squamosus, Pil. minutus, Pug. incisa,* and *L. haematosticta.* It is interesting to note that the four most abundant species in this bay, *N. e. japonica, C. prima, P. minutus* and *A. squamosus* are all separately grouped and they take the top of the order of abundance in each group of species composition, i. e. P. m.-group IV, V, VI, A. sq.-III, C. P.-VII, N. e. J.-II. This may suggest that the area where the high population density of a dominant species is found does not coincide with the high density areas of other species though the distributional ranges of these species overlap with each other.

Table 4. Values of the index of interspecific correlation (R_δ) between two species

Species	N. e. j.	A. g.	L. l	L. h.	Ac. t.	P. i.	C. v.	Act. s.	Pi. m.	Ca. p.
Dor. granulata	.701	.889	.619	.022	.436	.157	.747	.149	–.006	.308
N. e. japonica		.761	.806	.128	.584	.271	.025	.136	.101	.480
Ar. glabata	} Leucosiidae		.560	.283	.377	.201	.615	.247	–.106	.336
L. longifrons				.180	.635	.347	.649	.094	.087	.528
L. haematosticta					.262	.217	.049	.190	–.199	.411
Ac. tuberculatus						.316	.456	.267	.384	.564
Pug. incisa							.224	.307	.283	.293
Ch. variegata								–.006	.070	.385
Act. sqamosus	} Xanthidae								.304	.139
Pil. minutus										.015
Ca. prima										—

3. Seasonal variation of brachyuran fauna

Though the data to discuss on the seasonal faunistic variations are scarce, the first clue for solving the problem may be given by the following comparison. Data from three stations (Sts. 3, 7 and 9) were used for the faunistic comparison of September and December, for only these stations were sampled on 25th, December. Putting together these three samples, Morisita's C_λ index was calculated. The results are $\lambda_{sept.} = 0.119$, $\lambda_{dec} = 0.127$ and $C_\lambda = 0.701$. It is clear from these values that the seasonal variation of fauna in September and December is hardly recognized, and faunistic stability is made clear by nearly equal value of λ though there exists much difference in the number of individuals per sample between the two seasons.

By the data from another survey on Ariake sea conducted by research group of Seikai Regional Fisheries Research Laboratory in 1957–8, the value of C_λ between the brachyuran fauna of September and December was 0.29 (unpublished). But when the abundant two species (*Portunus hastatoides* and *Charybdis variegata*) in December were omitted, this became 0.82. The faunistic composition is also relatively stable in Ariake Sea except the influence of the imigrating Portunid crabs.

Conclusion and Summary

1. Recently, Thorson ('57) has stated on the benthic animal communities that the "level bottom" such as sandy or muddy bottom associated mainly with infauna animals lacks the numerous "microlandscape" which is the characteristic of epifauna environment (rocks, stone, shells, vegetation, etc.). But in Tomioka Bay, a fully developed epifauna (brachyuran) community was found on the "level bottom", and it was clarified that the community could be divided into eight groups of species composition that were closely connected with various environmental conditions.

The close correlation between the composition of marine animal population and the sediment in which it was found has been recognized (cf. Davis, '25, Jones, '52). This is much the same on brachyuran groups in this bay which were correlated with the texture of soil and faintly with the amounts of shells.

2. A graphic method to illustrate the abundance and percentage frequency of appearance of each species was used to clarify the characteristics of each species population in this bay. This method, which may be called "the quadrant-graph method", seems to be also convienient to compare the seasonal or local variation of the abundance of species in a community.

3. The tendency of distributional continum of species population (Whittaker, '52, and Thorson, '57) was also recognized. On the other hand, the groups of species composition could be extracted from the overlapping of these species distribution. A species group adapted to the biotop is formed in an area but the distribution of each species is not confined to that area but extends its range to the other areas gradually decreasing its density.

4. It was made clear that the brachyuran community of this bay forming an ecotone from sublittoral to more offshore community was consisted mainly of two families, Xanthid and Leucosiid.

And this faunistic characteristics was also recognized in Ariake Sea suggesting that it might be a common character of the shallow shelf zone in the west coast of Kyushu.

Acknowledgement

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AN ECOLOGICAL STUDY ON ANIMAL COMMUNITY OF *ZOSTERA* BELT, IN TOMIOKA BAY, AMAKUSA, KYUSHU (I)

Community composition (1) Fish fauna

By

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The community problem is one of the most important subject in ecology. Study of animal community is more difficult than plant community, because of the specific characters of animals, such as multiplicity of life mode, complexity of life cycle, movement, activity rythm etc.. So, there are few comprehensive studies on animal communities; especially, community study in marine ecology is not yet well-developed.

Elton[1] noticed discontinuity of nature and regarded it as complex structure of habitat patterns. Through this recognition of the relation between habitat pattern of nature and population interspersion of organisms, Elton[1] and Elton and Miller[2] advocated habitat approach to community study. They emphasized the importance of continuous ecological survey of community both in time and space. They wrote "the ultimate and proper aim of an ecological survey, ... is to ascertain and measure the population and dynamic relationships of all the species of organisms living in a place over some period of time."

Eel grass *Zostera* is flourishing in shallow water of bays, and "*Zostera* belt" has aroused attention of people for its conspicuousness of physiognomy and abundance of animal fauna.

Petersen[10] emphasized the significance of *Zostera* and benthic animals in it, as a basis of fishery production of inland sea. In Japan, Ohshima[8] and Research group of marine ecology, Kyoto Univ.[3),4)] pointed out importance of *Zostera* belt to coastal fisheries as a habitat of juveniles or subadults of fishes.

The author takes *Zostera* belt as one of common community types in coast, and tempted to make an ecological survey in Elton's meaning. Through this survey, local difference and seasonal change of community organization, life historical data and population fluctuation, dependence of each species to *Zostera* community, and ecological relations among these species will be clarified.

A community includes many phylogenic or ecological groups. It would be better to discuss them after distinguishing those ecological or phylogenic properties. As the most influential group, fish fauna is dealt with in this first report.

The author is much obliged to Dr. M. Morisita, for his judicious advice, on whole program and statistical treatment. This study is carried out under the collaboration of the Amakusa Marine Laboratory, Kyushu University. The author's grateful thanks are due to Dr. T. Habe, the chief of the laboratory, for his advice and making facilities available for accomplishing this work. The author is also obliged to the members of the laboratory for their persistent work on collecting and measuring samples. He is much indebted to Dr. Y. Dotsu, Department of Fishery, Nagasaki University, Dr. S. Mito, Department of Fishery, Kyushu University, Mr. T. Shiokawa, Amakusa Marine Laboratory, for their identification of specimens.

Description of the Field

Survey was carried out in Tomioka Bay, Kumamoto Prefecture, Kyushu. Tomioka bay is located at the north-western end of Amakusa Shimo-shima, and fronted in Chijiwa Bay. It is small and open-shaped bay, but west corner of the bay is surrounded by narrow sand spit, and forms there a calm baylet. Tidal difference is 3.3 m. in spring tide, 2.4 m. in neap tide.

There were three kinds of submerged plant communities, *Sargassum* belt, *Zostera marina* belt, and *Zostera nana* belt. The distribution of these vegetation in Tomioka Bay is shown in Figure 1.

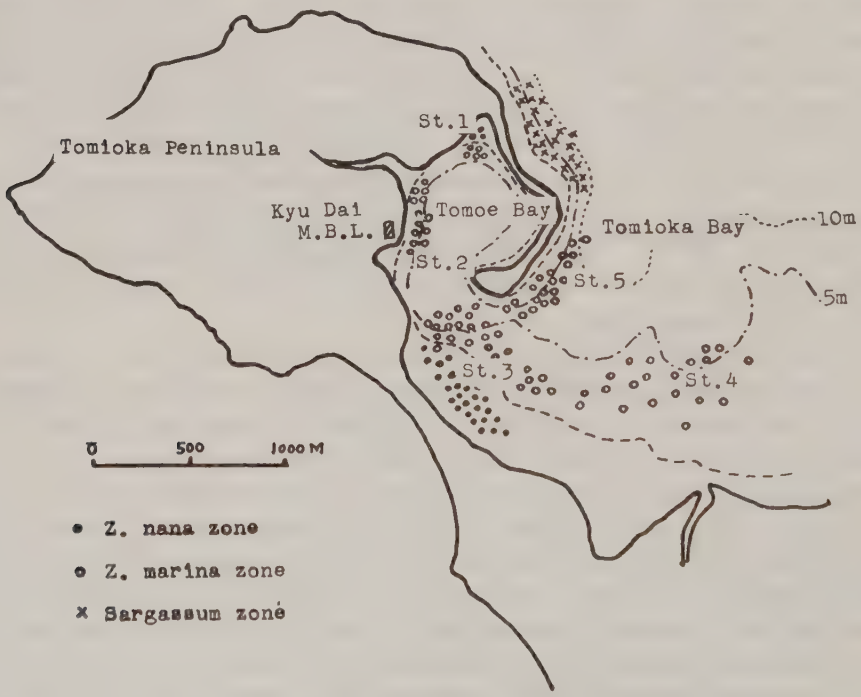

Fig. 1. Topography and distribution of sea weeds

Sargassum spp. grow on rocky reef or gravel bottom outside of the bay. Two species of *Zostera* grow sandy or muddy bottom in calm bay, but they grow separately. *Z. nana* spreads at intertidal zone, while *Z. marina* is most luxiriant in depth of 2–4 m., and its upper growth limit is lowest low tide level. As the first step of the study, *Z. marina* belt was dealt with in this survey.

According to the local characteristics of *Zostera* belt, five stations were settled for continuous survey. In the Tomoe baylet, there is a gentle slope near the shore line, then it suddenly becomes deep, and central part of the baylet has a flat muddy bottom about 8 m. in depth. In the baylet, *Zostera* grows only on the narrow shallow slope along the coast. Station 4 was settled at the central part of the bay. The bottom is sandy and flat (3–5 m. in depth) by the effect of tidal movement. *Zostera* spreads widely, but it is not so luxiriant on the sandy substratum, and makes patchy distribution. Station 5 was settled at outside of sand-spit. The slope of bottom is rather steep by the effect of tidal current, and *Zostera* grows in belt between 2 to 7 m. in depth. The substratum of shallow part is sand and of deeper part is mud. In lower end of *Zostera* belt, there is a zone of organic detritus. Some data of environmental factors of sea-water at these stations were shown in Table 1.

Table 1. Observation data of environmental factors

Substratum	St. 1	St. 2	St. 3	St. 4	St. 5
	mud	mud	sand	sand	sand (shallow) mud (deep)
Clorinity	St. 1	St 2.	St. 3	St. 4	St. 5
'59—VI—3, Surface	18.85 ‰	18.83	18.93	18.92	18.93
Bottom (Depth)	18.83 (3.0 m)	18.83 (2.3)	18.95 (2.7)	18.92 (4.4)	18.94, 18.97 (2.5) (5.4)
'60—I—10 Surface	18.81	18.68	18.76	18.81	18.80
Water temperature	St. 1	St. 2	St. 3	St. 4	St. 5
1958—X—18	22.3 °C	22.5	23.0	23.0	23.0
'58—XI—20	18.0	18.1	18.8	19.3	19.5
'58—XII—23	16.0	16.2	16.0	16.3	17.0 (deep)
'59—I—20	11.0	11.0	10.8	11.0	12.0
'59—II—20	12.8	14.0	14.1	15.0	15.0
'59—III—19	14.0	14.1	13.9	14.1	14.4
'59—IV—15	17.0	17.0	16.8	16.9	16.9
'59—V—20	19.2	19.2	19.0	19.0	18.9
'59—VI—21	22.8	22.3	22.0	22.0	21.8
'59—VII—19	25.9	25.7	25.4	22.0	22.0
'59—VIII—19	26.7	25.9	25.7	25.8	25.7
'59—IX—15	27.4	27.4	27.5	27.4	27.3
'59—X—15	22.2	22.2	22.0	22.1	22.5

Collecting Method

Collection was carried out by a kind of small Danish seine (front width 120 cm., height 70 cm., side net 120 cm., mesh of main part of the seine is 1 cm. square, and end of the bag is 2 mm. square). The seine was drawn 3 minutes by a small engine boat, in lowest speed at each station. Net drawn distance was about 100 m. Collecting was carried out once a month both in day and night at full tide of spring tide, once a month daytime only at mean tide of neap tide.

Fish Fauna in Zostera Belt and its Local Difference

The catches by Danish seine during 13 months (from October 1958 to November 1959) were listed in the appendix 1. Comparing the fish fauna of five stations, there are some differences in number of species and number of individuals among those stations. The similarity of community composition was then examined.

As for the expression of similarity or difference between communities, many indice have been diviced. Jaccard[5], Sorensen[11] and others used number of common species to total species, and Odum[7] and Whittaker[12] used not only the number of species but also the number of individuals in their indice. In all cases, however, the values of indice were much affected by sample size. Recently, Morisita[6] proposed a new index which is almost unaffected by sample size. This new similarity index C_λ is adopted in this study. Putting $\lambda_1 = \Sigma n_{1i}(n_{1i}-1)/N_1(N_1-1)$, $\lambda_2 = \Sigma n_{2i}(n_{2i}-1)/N_2(N_2-1)$, where λ_1 and λ_2, N_1 and N_2 are λ and N of the sample I and II, and n_{1i} and n_{2i} are the numbers of individuals of species i found in the sample I and II respectively, the index of similarity is given as $C_\lambda = 2\Sigma n_{1i} n_{2i} / (\lambda_1 + \lambda_2) N_1 N_2$.

The value of C_λ will be about 1 when the two samples belong to same community and will be zero when no common species is found between them.

At first, similarity of two series of samples caught in the same place and time was examined. At station 3, 4 and 5, the two samples were collected at once. The data by first and second sampling during the period were summed

Table 2. Values of the index of community similarity

2-A Values of the index of community similarity among the samples from the same station.

	3b	4b	5b	λb
3a	0.98			0.21
4a		0.96		0.19
5a			0.99	0.23
λa	0.19	0.23	0.27	

2–B Values of the index of community similarity among five stations

	St. 1	St. 2	St. 3	St. 4	St. 5
St. 1		0.51	0.62	0.21	0.36
St. 2			0.96	0.70	0.78
St. 3				0.67	0.76
St. 4					0.89
λ	0.22	0.18	0.20	0.20	0.25

up respectively, and similarity index between them was calculated (Table 2–A). The values of λ in these pairs were very similar and C_λ showed very high similarity. This result assured that sampling error could be ignored in this collecting. Then similarity between communities of five stations were calculated using the data of appendix Table 1 (Table 2–B).

Except the station 1, which indicated a little low index values among other stations, these local communities showed high similarity values. Especially, neighbouring two stations showed very similar value.

Referring to each species, *Plotosus anguillaris*, *Rudarius ercodes*, *Pseudoblennius cottoides* were dominated in all stations. High values of similarity index were due to the overwhelming majority of these species. *Pterogobius zonoleucus*, *Chaenogobius heptacanthus*, and *Gerres macrostoma* were abundant inner part of baylet. On the other hand, *Dumaeria flagellifera*, *Halichoeres tenuipinnis*, *Vellitor centropomus* and *Pseudoblennius percoides* were mainly appeared outside of baylet, such as station 3, 4, and 5. *Hypodytes rubripinnis* was most abundant at station 3 and 4, a sandy bottom of outside station.

Seasonal Change of Fish Community

Seasonal change of fish community in *Zostera* belt was examined. The importance of a species in one local community may be measured by many criteria, such as density, biomass, frequency of appearance, influencing power to community structure. In this study, community organization is illustrated by Ono's quadrant graph method[9] with some modifications, and taking the percentage frequency (number of samples that species found/number of whole samples) in ordinate, and number of individuals in abicissa. The former was divided by 50% line and latter was divided by mean number of individuals. Thus the graph was divided into four areas. Each species was plotted on this graph, and size of points indicates the total weight of that species. The species plotted on the first area are abundant and frequently appeared species, and this area may be called "dominant area". The species which appeared occasionally in school are restricted in the second area. The third area includes rare species, and fourth

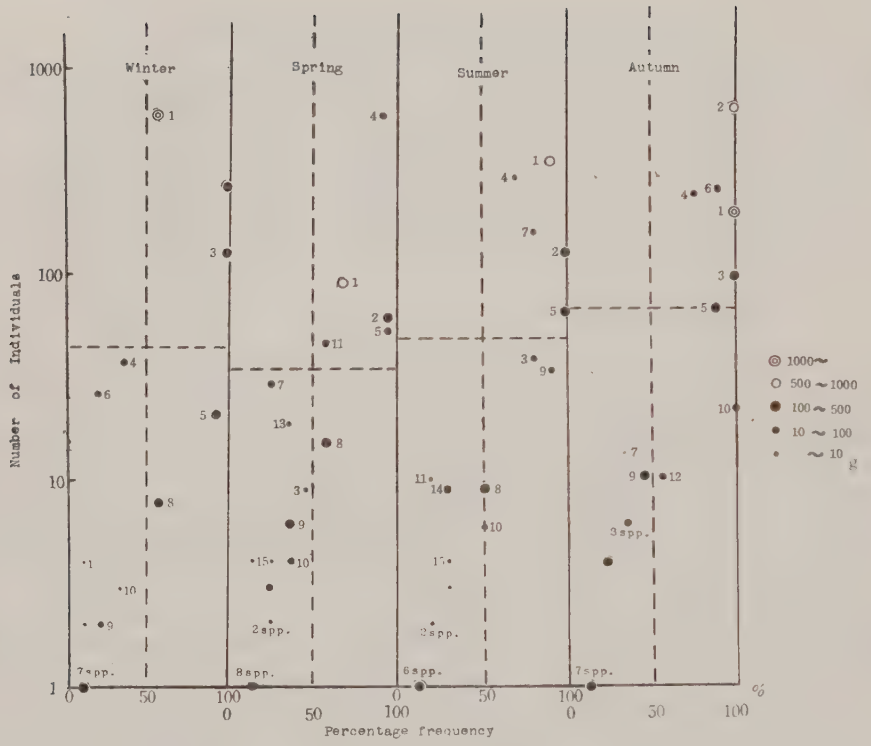

Fig. 2. Seasonal change of fish community in Station 2

Species: 1. *Plotosus anguillaris* 2. *Rudarius ercodes* 3. *Hypodytes rubripinnis* 4. *Caenogobius heptacanthus* 5. *Pseudoblennius cottoides* 6. *Gerres macrostoma* 7. *Pterogobius zonoleucus* 8. *Sebastes inermis* 9. *Pseudoblennius percoides* 10. *Hippocampus coronatus* 11. *Chasmichthys gulosus* 12. *Stephanolepis japonicus* 13. *Aulichthys japonicus* 14. *Stephanolepis cirrhifer* 15. *Trachyrhamphus serratus*

area includes the species which is not so high in density, and yet appeared frequently through the period. It may be called "characteristic species area."

Seasons were defined following, spring (March–May), summer (June–August), autumn (September–November), and winter (December–February), and samples were examined by season and by station. Seasonal change of fish community at station 2 was shown in Figure 2.

Plotosus anguillaris, Rudarius ercodes, Hypodytes rubripinnis and *Chaenogobius heptacanthus* were abundant through the year. *Pseudoblennius cottoides* was plotted in first or fourth area through the year. The juveniles of *Pterogobius zonaleucus* and *Aulichthys japonicus* appeared in school in spring and summer.

Seasonal fluctuation of most species in *Zostera* belt seemed to be caused by their life cycle. Ohshima[8] emphasized the importance of *Zostera* belt as the habitat of juvenile or subadult stage of many fishes. It was found that the

number of species was maximum in spring and in early summer, and minimum in winter. This tendency was conspicuous at outer parts of the bay, stations 3, 4, and 5. This change was caused by the immigration of juvenile fishes of many species. Most of them spent subadult stage in *Zostera* belt, and go to their original habitats of adult in summer or autumn.

Sebastes pachycephalus, Sebastiscus marmoratus, Agrammus agrammus, Stephanolepis cirrhifer, S. japonicus, Goniistius zonatus etc. spend their adult life in rocky coast zone where *Sargassum* spp. grow, and *Neoclinus bryope, Chasmichthys glosus* in sublittoral zone with gravels and mud.

According to the report of research group of Kyoto Univ.,[3), 4)] *Sebastes inermis* is one of the typical those temporally species in *Zostera* belt, in Kasaoka Bay. Many subadults of this species appeared to *Zostera* belt, at the end of March, and went out in July all at once. In the present study, *Sebastes inermis* was low in density, however it stayed in *Zostera* until its first spawning season. This difference is considered to be due to difference of oceanographic conditions or food relations. Of course, there were many *Sebastes* in rocky coast, and *Zostera* was not their main habitat. The period and total length of subadult fishes appeared to *Zostera* belt were listed in appendix Table 2. Most of these species spend pelagic life at their early life stage. The process of immigration of juvenile fishes to *Zostera* will be ascertained by the larvae net sampling now in process.

Catch by Gill-net

The samples mentioned above were catches by Danish seine. However, species and body size of animals were limited by the structure and mesh of nets, drawing speed of boat, etc.

To supply the bias of species composition by collecting method, gill-net, common fishery instrument in this coast, was used at station 2, at the same time with seine collecting. (The mesh of the net is about 10 cm. square, 1.2 m. in height, 120 m. in length.) The net was set straight along the *Zostera* belt, and samples were collected 8 hours after setting. By this method, 48 species were caught, among them 18 were newly recorded. There were conspicuous diurnal periodicity among these species, catches were scarce in the daytime.

Sasonal fluctuation was also found in these species. *Sebastes inermis* and *Sebastiscus marmoratus* were caught frequently in winter, and most of them had ripen gonad. *Inegocia japonica* which invaded in June to July had also ripen gonad.

Chrysophrys major, Stephanolepis cirrhifer etc. were caught during the short period in late autumn. Judging from the body size and period of appearance, they are supposed to be subadult just before leaving from *Zostera* belt. *Mugil cephalus, Gerres japonicus, G. macrostoma, Leignathus argentea* etc. were found in winter. They are benthic feeders, and forage around the bay in school. *Gerres* spp. made small groups of 10 to 20, while a school of *Leignathus* was large in number. These species were also caught at estuary near by, at flow

tide. Inegocia japonica, *Fugu nephobles* etc. are also found in intertidal zone, at flow tide.

Generally speaking, the species caught by gill-net were big in size, with large swimming ability, and they forage in bay widely.

Significance of Zostera Belt as a Habitat of Fishes

From data already mentioned, relationships between *Zostera* belt and life of fishes are summarized as follows:

1. Fishes which spend whole life in *Zostera* belt
   a. Fishes which live in *Zostera* as a main habitat
      Rudarius ercodes, Plotosus anguillaris, Pseudoblennius cottoides, P. percoides, Hypodytes rubripinnis, Syngnathus schlegeli, Hippocamphus coronatus, Aulichthys japonicus, etc.,
   b. Fishes common with rocky reef
      (*Sebastes inermis*), *Duymaeria flagellifera, Halichoeres tenuipinnis* etc.,
   c. Fishes common with muddy or sandy bottom
      Chaenogobius heptacantus, Rhinogobius pflaumi etc.,
2. Fishes which spend special life-stage in *Zostera* belt
   a. In spawning season
      Sebastes inermis, Sebastiscus marmoratus, Inegocia japonica
   b. In juvenile and subadult stage
      Stephanolepis cirrhifer, S. japonicus, Gerres macrostoma, Goniistius zonatus, Chasmichthys gulosus etc.,
3. Fishes which forage larger area in the bay (Fishes come to *Zostera* belt as a part of their habitat.)
   Gerres japonicus, G. macrostoma, Inegocia japonica, Fugu pardalis, F. niphobles, Agrammus agrammus, Ditrea temmincki etc.,
4. Fishes which accidentally appear to *Zostera* belt
   Diodon hystrix, Ostracion tuberculosus, Paralichthys olvaceus, juveniles of pelagic fishes etc.,

Population fluctuation and other ecological notes on main species will be reported in another paper.

Summary

1. Continuous survey on animal communities in *Zostera* belt was carried out at Tomioka bay, Amakusa Shimo-shima, west coast of Kyushu.

2. Referring to the fish fauna, 86 species were collected by small Danish seine, and 48 species were collected by gill-net. Local difference in the bay was examined by community similarity index.

3. Seasonal change of fish community was studied. In all stations, *Rudarius ercodes, Plotosus anguillaris, Hypodytes rubripinnis* were dominated through the year. Juveniles or subadults of many fishes appeared in *Zostera* belt were recorded concerning the body size and time of appearance in *Zostera* belt.

4. Fishes were classified according to their dependency on *Zostera* belt.

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Appeidix 1. Fish fauna in *Zostera* communities caught by small Danish seine

Station	1	2	3	4	5
Species \ Number of Samples	41	42	81	75	79
Etrumeus micropus				4	1
Plotosus anguillaris	470	1299	3873	616	2417
Anguilla japonica		2	2		
Astroconger myriaster			1		
Hemiramphus sajori				1	
Aulichthys japonicus	3	22	84	60	448
Syngnathus schlegeli	2	10	49	90	76
Trachyrhamphus serratus	2	10	45	84	136
Hippocampus coronatus	19	41	28	13	18
Sphyraena japonica			1		
Trachurus japonicus				4	1
Psenopsis anomala					1
Upeneus bensasi					3
Upeneus tragula			13		2
Pseudoupeneus spilurus			4		
Apogon niger				16	7
Apogon lineatus	1			2	
Apogon endekataenia	5	1	15	7	151
Apogon semilineatus			3		5
Priacanthus hamrur					1
Scombrops boops					3
Epinephelus fasciatus			1		
Epinephelus septemfasciatus	1		1	2	
Sillago sihama			67		
Girella punctata					1
Gerres japonicus		1	2		
Gerres macrostoma	1119	264	362		74
Lutianus russellii		5	6	1	
Lethrinus nematocanthus			2	19	38
Therapon oxyrhynchus			1		
Mulio macrocephalus		2	3		
Mylio latus			1		
Chrysophrys major					1
Goniistius zonatus		1	3	8	13
Gilias snyderi					1
Callionymus richardsoni			1		1
Neoclinus bryope			1		3
Dasson trossulus	11	7	23	8	10
Zoarchias neglectus ?					1
Enedrias nebulosus	2		13	19	36
Rhinogobius pflaumi	12	13	41	13	29
Acanthogobius flavimanus			3		
Acentrogobius campbelli		1			
Pterogobius zonoleucus	262	249	451	11	94
Chaenogobius heptacanthus	683	1142	3646	170	133
Chasmichthys gulosus	3	53	94	22	7
Sagamia genonema		12	12	14	19
Leucopsarion patersi	1	5	1		

Appendix 1. continued

Species \ Station	1	2	3	4	5
Ditrema temmincki	3	34	82	114	7
Duymaeria flagellifera	3	1	15	14	174
Pseudolabrus japonicus		2	4	1	3
Stethojulis kalosoma			1		
Halichoeres tenuispinnis		7	39	36	166
Halichoeres poecilopterus		1	3		25
Heniochus acuminatus			1		
Prionurus microlepidotus		2	1		
Siganus fuscescens	1	1	114	5	79
Paramonanthus oblongus				2	1
Stephanolepis cirrhifer	17	10	19	25	48
Stephanolepis japonicus	12	11	52	90	200
Rudarius ercodes	289	1127	3307	1576	4275
Nacodon modestus				1	
Brachaluteres ulvarum					4
Ostracion tubercularis					1
Canthigaster rivulatus	2	2	2		2
Fugu niphobles	5	4	30	20	16
Fugu pardalis	1	4	4	2	2
Arothoron stellatus	1		11		
Diodon hystrix	1				1
Sebastes inermis	6	33	63	39	142
Sebastes pachycephalus					7
Sebastes hubbsi				1	3
Sebastiscus marmoratus	2	2	5		5
Inimicus japonicus			5		1
Erosa erosa			1		3
Hypodytes rubripinnis	7	358	1456	1338	328
Agrammus agrammus		2	6	1	5
Inegocia japonica		2	8	3	7
Platycephalus sp.					1
Vellitor centropomus		5	2	48	218
Bero elegans					13
Pseudoblennius percoides	13	52	250	237	239
Pseudoblennius cottoides	76	226	266	125	267
Paralichthys olvaceus			2		2
Pseudorhombus cinnamoneus					1
Pleuronichthys cornutus					1
Total number of individual	3075	5026	14602	4858	9975
Total number of species	32	41	61	42	63

Appendix 2. Juveniles or subadults of fishes appeared in *Zostera* belt

Species	Period	Total length	Abundance**
Etrumeus micropus	IV(L) — V(L)*	37 — 53mm	—
Plotosus anguillaris	VII(M) —	12 — Adult	##
Aulichtys japonicus	II(L) —	8mm — Adult	++
Syngnathus schlegeli	VI(L) —	28mm — Adult	+
Trachyrhamphus serratus	II(L) —	30mm — Adult	+
Hippocampus coronatus	V(M)	12mm — Adult	+
Sphyraena japonica	IX(L)	50mm	—
Trachurus japonicus	IV(M) — V(L)	17 — 59mm	—
Psenopsis anomala	X(M) —	29mm	—
Upeneus tragula	X(M) — IX(L)	64 — 94mm	±
Apogon niger	III(L) —	40mm — Adult	—
Apogon endekataenia	VII(M) —	16mm — Adult	±
Apogon semilineatus	VIII(M)	10 — 30mm	—
Scombrops boops	II(E) — II(L)	16 — 25mm	—
Epinephelus septemfasciatus	VII(M) — IX(L)	69 —	±
Sillago sihama	VIII(L)	26 — 32mm	+
Gerres macrostoma	VIII(L) — II(L)	15 — 68mm	##
Chrysophrys major	VI(L) — VIII(L)	56 —	—
Lutianus russellii	X(M) — IX(M)	39 — 74mm	—
Lethrinus nematacanthus	X(M) — IX(L)	27 — 75mm	±
Goniistius zonatus	I(L) — VII(L)	49 —148mm	±
Neoclinus bryope	IV(L) — V(L)	10 — 30mm	—
Dasson trossulus	X(M) — IX(L)	32 — 74mm	±
Enedrias nebulosus	III(M) —	12 — Adult	±
Rhinogobius pflaumi	X(L) —	8mm — Adult	±
Pterogobius zonoleucus	III(L) —	13mm — Adult	++
Chaenogobius heptacanthus	III(M) —	8mm — Adult	##
Chaeturichthys sciistius	VI(M)	32mm	—
Chasmichthys gulosus	IV(M) — VI(M)	19 — 37mm	+
Sagamia genionema	IV(L) —	34mm — Adult	±
Ditrema temmincki	IV(M) —	36mm — Adult	+
Duymaeria flagellifera	VIII(M) —	33mm — Adult	±
Halichoeres tenuispinnis	VIII(M) —	13mm — Adult	±
Siganus fuscescens	VII(M) — IX(L)	20 —152mm	+
Stephanolepis cirrhifer	VI(L) — IX(L)	21 —132mm	+
Stephanolepis japonicus	VII(L) — IX(L)	20 — 58mm	++
Rudarius ercodes	VII(M) —	8mm — Adult	+
Brachaluteres ulvarum	VIII(M) — IX(L)	22 — 40mm	—
Canthigaster rivulatus	V(M) — VIII(M)	33 — 54mm	—
Fugu niphobles	VII(E) —	11mm —	—
Fugu pardalis	VI(L) — X(M)	38 —104mm	—
Sebastes inermis	III(L) —	23 —202mm	+

Species	Period	Total length	abundance**
Sebastes pachycephalus	Ⅱ(L) — Ⅳ(M)	30 — 51mm	—
Sebastiscus marmoratus	Ⅳ(L) — Ⅴ(L)	41 — 59mm	—
Hypodytes rubripinnis	Ⅷ(L) —	20mm — Adult	++
Agrammus agrammus	Ⅱ(L) — Ⅺ(L)	48 —129mm	—
Platycephalus sp.	Ⅸ(M)	46mm	—
Vellitor centropomus	Ⅳ(L) — Adult	29mm — Adult	+
Pseudoblennieus percoides	Ⅱ(L) — Adult	16mm — Adult	++
Pseudoblennieus cottoides	Ⅱ(L) — Adult	10mm — Adult	+
Pseudorhombus cinnamoneus	Ⅹ(L)	79mm	—

**Mark of abundance: (—) 0 — 10 (±) 10 — 50 (+) 50 — 100
(++) 100 — 1000 (+++) 1000 —

*(E) early (first decade)
(M) middle (second decade)
(L) late (third decade)